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A TREATISE ON THE

PROGRESSIVE IMPROVEMENT & PRESENT STATE

OF THE

MANUFACTURES IN METAL.

VOL. II.

IRON AND STEEL.

NEW EDITION.

REVISED BY ROBERT HUNT,

Professor of Mechanical Science, Government School of Mines.

1853.

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NOTICE.

In this volume the more important additions which have been made are confined to Agricultural and Weaving Machinery. There will, however, be found much that is new in connection with the subjects of Locks, Printing Presses, and several varieties of Birmingham manufacture.

Care has been taken to introduce some notice of each novelty in Iron Manufacture, and to describe any improvement in the processes employed.

The several scientific gentlemen and manufacturers who have in all cases readily furnished the required information have my acknowledgments and thanks.

R. H.

August, 1853.

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A
TREATISE
ON THE
MANUFACTURES IN METAL.

IRON AND STEEL.

CHAP. I.

ORIGINAL CUTTING INSTRUMENTS. — SWORDS. — CARVER. — EARLY ENGLISH CUTLERY. — SHEFFIELD. — MARKS. — CLASP, OR SPRING KNIVES. — TOOLS. — FACTORING SYSTEM. — KNIVES. — SECTIONS OF BLADES. — FORKS. — KNIFE SHARPENERS.

ALTHOUGH we may not be able to produce the testimony of the very earliest ages for the introduction of knives at table, or for domestic purposes, it is certain that the use of edged instruments in slaughtering animals, whether for food or sacrifice, as well as for cutting up their flesh, must have had a very remote origin. These, however, were by no means at first fabricated either of iron or steel, or even of metal, but rather of shells, flints, and other like materials, all classed by writers under the common appellation *knives*. That this is probably the true meaning of the term in several early passages of Scripture, may be generally inferred from the literal rendering of Exod. iv. 25.

Even at the present time, in many savage nations, where the existence or the smelting of iron is unknown, the carving instruments of the natives are, as all readers of voyages and travels, and visitors of museums, must recollect, made of the above-named substances.

Nor are the edged stones which have so frequently been brought to this country from the various uncivilised parts of the world by any means so defectively formed for their purposes as might be imagined; indeed, they are often brought toward the form aimed at by the workman, with a degree of perfection which is really surprising, especially when we regard them as the result of an application of the rudest possible methods of manufacture.

Next to shells and sharp stones, brass, or bronze, furnished the material of instruments for the arts and domestic purposes, and of the warlike weapons of many of the nations of antiquity. Bronze instruments, varying considerably in form, are frequently found in different parts of our own islands, as well as on the Continent, to which the general name of *celts* have been given. This name has led to the belief that they were the weapons or instruments of the Celtic races, of which, however, we have not the slightest evidence. That they were employed by some people at a very remote antiquity is certain, since they have been found, at such a depth beneath the present surface, that many thousands of years must have been necessary for the accumulation of so large a quantity of matter above them. None of these celts have anything like the form of the modern knife; they were, judging from the shapes discovered, employed as chisels, hammers, and probably spears. Wherever they are found, these celts have the same chemical composition — tin and copper, and hardened at the edge by a process of hammering. Many of them are highly ornamented, showing much skill in the caster. The application of the term celts to the stone instruments is objectionable, as confounding things of a most dissimilar character, and certainly belonging to widely different periods. It has already been intimated that the Greeks, at the period of the Trojan war, were little, if at all, acquainted with iron and steel, though brazen implements of different sorts were common amongst them. Moreover, that the monuments of Egypt themselves were cut with chisels of brass, hardened by some process no longer known, has been asserted; and that many of the battles which have now become so famous in the records of ancient history were fought by warriors armed with bronze swords there can be no doubt. Whether the "nine-and-twenty knives" (Ezra, i. 9.), which were carried by the Jews to Jerusalem on their return from the captivity in Babylon, were of brass or iron does not appear; nor whether they were the sacrificing instruments which had been taken away with other things from the temple, though this seems probable, — at all events, the mention of these knives, along with such vast treasures of gold and silver, shows that they were accounted valuable.

It has, as we have just said, been disputed whether iron or steel were at all known to the ancient Greeks. The authority of the Homeric poems has been cited both for and against the affirmative presumption. The epithet *αἶθω*, *I burn*, has been urged, on the one hand, as referring to brass, from the yellow colour of flame; and on the other, to iron, as simply expressive of brightness, *I shine* being considered to be the more exact sense of the Greek *αἶθω*. It may be remarked, on the authority of ancient writers both in prose and verse, that the swords of warriors, of whatever material fabricated, were not unfrequently used with the utmost convenience for the double purpose of slaughtering their enemies and carving their meat.

Caliburn, the sword of king Arthur, and the sword of the renowned Pendragon, were as serviceable in the kitchen as in the field, if we may credit their poetical historian John Grub, heretofore of Christ's Church, Oxford, who says of the latter —

"His sword would serve for battle, or for dinner, if you please;
When it had slain a Cheshire man, 't would toast a Cheshire cheese."

The all-work dagger of Hudibras seems to have been equally adroit and accommodating with the swords of the fore-mentioned Cambro-Britons: —

> "It was a serviceable dudgeon,
> Either for fighting or for drudging;
> When it had stabb'd or broke a head,
> It would scrape trenchers, or chip bread,
> Toast cheese or bacon, though it were
> To bait a mouse-trap, 't would not care."

At an early period, however, of Rome's ancient glory, not only was the table-knife,—whether made of iron or steel, is uncertain,—and the domestic office of *carver*, actually instituted. Whether, indeed, this important functionary merely separated the meat into large portions, as is commonly done by his representative in modern times, or whether he did not cut the meat into smaller morsels, so as to be quite ready for the mouth, are questions about which writers on the gastronomic science are not agreed: from the recumbent positions adopted at meals, the latter conjecture is far from improbable. The use of knives, and the existence of the office above mentioned, were not uncommon at great men's tables at a very early period, even in this country. One of the earliest specimens of typography in the English language is a little black-letter volume printed by Wynkin de Worde, A. D. 1508, entitled "A Boke of Kerving."

From an era, not now to be ascertained, down to the time of queen Elizabeth, we had an import trade in knives; and, as the historian of Hallamshire remarks, "the knyves of Almagne, knyves of France, knyves of Collagne, are among the articles enumerated in the custom-house rate books of the time of Henry VIII. Queen Elizabeth, in the fifth of her reign, laid some restrictions on this import trade, but more, as it seems, with a view to encourage the London manufacturers, than those of the country. London was, at that time, the principal mart of the finer species of cutlery; but, besides London, Salisbury, Woodstock, and Godalming were rivals with Sheffield in this department of our national manufactures." At what period our native *manufacture* of these important wares was introduced it is impossible to say. In Stow's "Chronicle" occurs the following passage: — "Richard Matthews, on Fleete Bridge, was the first Englishman who attaigned the perfection of making fine knives and knive hafts; and in the fifth year of queen Elizabeth he obtained a prohibition against all strangers, and others, for bringing any knives into England from beyond the seas, which until that time were brought into this land by shippes lading from Flanders and other places. Albeit at that time, and for many hundred yeeres before, they were made, in divers parts of this kingdome, many coarse and uncomely knives; and at this day the best and finest knives in the world are made in London." Although the chronicler, in this passage, directly refers to the early existence and extent of the cutlery trade, inconsiderate copyists have drawn from it a loose statement to the effect that "knives were first made in England, in 1563, by Thomas Matthews, on the Fleet Bridge, London." Against this assertion, besides the testimony of Stow, and the common traditions of the Hallamshire cutlers, has to be set the undoubted fact, that, so early as the year 1417, the cutlers of the metropolis sought and obtained a charter of incorporation from Henry V. It may be added, that they have a hall in Cloak Lane, and admit freemen, on the payment of a livery fine of 10*l.* That knives were made at Sheffield at least a century earlier than the preceding date, appears indisputable from the incidental testimony of the poet Chaucer, who, in his "Reve's Tales," states of the miller of Trompington, that, among other accoutrements, —

"A Shefeld thwytel bare he in his hose."

The description of knife mentioned by the poet was evidently that used for cutting food, or a *case-knife*, as it was long afterwards called, from being fitted with a sheath. The distinction which Stow, in the passage before quoted, has drawn between "fine" and "coarse and uncomely knives" is too vague to enable us to attach an exact meaning to his words.

In the year 1575, if not at an earlier period, Sheffield was certainly celebrated for the fabrication of these wares; for the earl of Shrewsbury, under that date, sends to his friend lord Burleigh, "a case of Hallamshire whittells, beinge such fruietes as his pore cuntrey affordeth *with fame throughout the realme.*" It is probable, indeed, that, at this time, the manufacture consisted, for the most part, of the coarser and inferior kinds, such as knives which, as Fuller says, were "for common use of the country people," and which excited his surprise when he saw them offered at the low price of one penny.

"Sheffield," as Mr. Hunter justly remarks, "possesses natural advantages of a superior order to those which perhaps any other spot in the island can boast, for that peculiar species of manufacture which has fixed itself there. It had acquired an extended reputation for those manufactures as early as the reign of Edward III.: and the princes of the house of Tudor displayed at all times a generous concern for the protection of commerce, and the encouragement of those engaged in it." Although the incorporation of the cutlers "within Hallamshire," a certain district lying around Sheffield, did not take place before 1624, yet special regulations for the better government of the craft are extant in the Manor court-roll from a period considerably antecedent to that date. In the 32d of Elizabeth the existing laws were recited at length, and a series of "actes and ordinaunces" agreed upon, "as well by the hole fellowshippe and company of cutlers and makers of knyves with the lordshippe of Hallomshire, in the countye of Yorke, as also by th' assente of the righte honourable George eerle of Shrewsburye, lord and owner of the lordshippe of Hallomshire, for the better relief and comodytie of the porer sort of the said fellowshippe." In 1624, the year above mentioned, the manufacturing population of Sheffield and the neighbourhood incorporated themselves by virtue of an "Act for the good order and government of the makers of knives, sickles, shears, scissors, and other cutlery wares, in Hallamshire, and parts near adjoining."

The preamble of this act sets forth, "That the greatest part of the inhabitants of those said parts consists of persons engaged in the different departments of the cutlery manufacture; and that by their industry and labour they have not only gained the reputation of great skill and dexterity in the said faculty, but have relieved and maintained their families, and have been enabled to set on work many poor men inhabiting thereabout, who have very small means or maintenance of living, other than by their hard daily labour as workmen to the said cutlers; and have made knives of the very best edge, wherewith they served the most part of this kingdom, and other foreign countries; until now of late that diverse persons using the same profession, in and about the said lordship and liberty, not being subject to any rule, government, or search of others of skill in these manufactures, have refused to submit themselves to any order, ordinance, or search; by means of which want of government the said workmen are thereby emboldened and do make such deceitful and unworkmanly wares, and sell the same in divers parts of the kingdom, to the great deceit of his majesty's subjects, and scandal of the cutlers in that lordship and liberty, and disgrace and hinderance of the sale of cutlery, and iron and steel wares there made."

One important proviso of the act requires "all persons engaged in the said businesses to make the edge of all steel instruments, manufactured by them, of steel, and steel only; and to strike on their wares such mark, and such only, as should be assigned to them by the officers of the company." These corporation marks were, in some cases, of considerable value, at an after period, as attesting the superiority of the wares upon which they were stamped: an exemplification of this fact has already been noticed, in the amount of damages awarded in a court of justice for the infringement of a file mark. Another instance, in which one of these marks led to a discovery connected with an assassination which holds a prominent place in the annals of this country, may be mentioned as occurring soon after the passing of the above-mentioned act. In 1626, one Thomas Wild, living in the Crooked-billet Yard, High Street, Sheffield, made for lieutenant Felton the knife with which he stabbed the duke of Buckingham. When the duke fell, the knife was found in his body; and on examination it bore a corporation mark, which being observed, naturally led to further enquiries on the subject. Reference was first made to the London cutlers, as to whether the knife had been made in the metropolis; they all, however, agreed that it had been made at Sheffield, and doubted not but the corporate mark would soon lead to a discovery of the real maker. An express was accordingly sent to Sheffield, the necessary enquiries made, and the poor cutler, Wild, presently sent up to London, and to the earl of Arundel's house to be examined. Wild at once acknowledged the mark to be his, and stated that it was one of two knives he had made for lieutenant Felton, who was recruiting in Sheffield, and for which he had charged him ten-pence. The earl was well satisfied of the truth and simplicity of Thomas Wild's testimony, and ordered him to be paid the expenses of his journey home.

While on the subject of marks, it may not be amiss to remark, that a laxness in the regulations concerning them (if, indeed, any regulations may be said to exist,) has led not only to great confusion, but in some cases to considerable abuse. Whatever may be said in favour of the policy of a manufacturer striking the name of his customer upon articles of which the latter passes with the public for the maker, no reasoning can justify the use of a mark calculated to deceive the purchaser, either as to the nature of the material or the signification of the monogram itself. It is not intended by this remark to object to any manufacturer's right to call his article by what taking or significant name best suits him, but to protest against the stamping of "cast steel" upon articles perhaps containing little or no steel of any sort, as well as the fraudulent imitation of reputable marks upon worthless wares. The policy as well as the justice of some regulation of this kind has been more particularly contended for in reference to the articles commonly cast of a worthless material. In 1817, a petition, signed by 10,000 merchants and manufacturers, was presented to parliament, praying that manufacturers of cast metal cutlery might be compelled to put some distinguishing mark upon their goods. No regulation, however, followed. Seven years afterwards, a petition was presented to the Commons, praying for a less satisfactory if not less reasonable measure, namely, that a bill should be passed to prevent retailers and others (not being actual manufacturers of cutlery) from stamping or marking goods with their own names. A bill to this effect was presented; but being strongly opposed by the London cutlers, it was withdrawn in the committee.

There is another practice so directly illegal, as well as shameless, that it ought not to be tolerated among respectable tradesmen; that is, the unauthorised use of the word "patent." Specifications, ridiculous and worthless enough, are, it is true, often enrolled at the patent office, as well as many inventions and improvements of great value; but still, as they are alike dearly paid for, it is only fair that those who purchase the distinction, whether valuable or not, at so high a price, should be protected in their exclusive use of it. This does not apply to the new patent laws, which enables any one to obtain a patent at a moderate cost; the remarks on the dishonesty of some manufacturers hold perfectly good, though patents are not so costly as when these paragraphs were written.

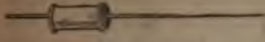
Not only were the larger and commoner sorts of knives fitted with sheaths, but also *pen-knives*, which were fastened into the hafts, in the manner of what are now called *desk-knives*; so that they could not be put into the pocket without a case or covering: this is evident from various representations in old pictures and prints. At what period that simple but effective contrivance by which they are now made to shut up so neatly and conveniently was introduced does not appear. Harrison intimates, that about the year 1650 *clasp* or *spring* knives began to be made with handles of iron, which in a little time they covered with horn, tortoise-shell, &c. In the old Scottish dialect, a clasp-knife was called a *jockteleg*, this barbarism being a corruption of *Jacques de Liege*, according to tradition a famous cutler in the Netherlands, whose knives were the first of this sort known in Scotland. Burns, in his epistle to Captain Grose, jocularly intimates that the veteran antiquary possessed, among other equally veritable rarities, the knife of Cain, and that

"It was a faulding *jockteleg*,
Or laug-kail gulley."

It has been said, that, however humble a shoemaker's employment, and however simple and familiar his tools and operations, it would be next to impossible to teach the art of making shoes by means of written and engraved descriptions, though these should be never so correct and elaborate. The same remark may be made, with still greater force, in reference to the craft of the cutler. The least complex penknife, which, after having been made by a poor ragged work-board man, regularly apprenticed to the trade, is sold for sixpence, would probably all but defy the ingenuity of a first-rate machinist to imitate it in all its parts and perfections; so much depends upon the manual dexterity acquired by long practice in a handicraft art, which almost excludes the application of machinery.

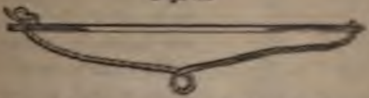
The tools of an ordinary cutler are few and simple, probably differing but little at the present day from those which furnished the work-board in the earliest era of the manufacture; amongst these may be mentioned a *vice*, similar to those usually seen in a smith's shop; the *breast-plate*, different sized *piercers*, and a *boring stick*. These articles are so indispensable to the knife maker, and so significant of the craft, that were a cutler to see any thing like them on Cleopatra's needle, he would instantly consider them as the hieroglyphical symbols of a fraternal trade in the land of Egypt. The piercer,

Fig. 1.



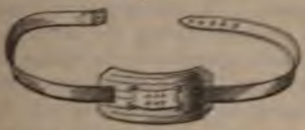
or *parser*, as the user calls it, consists of a flattish-pointed spindle about eight inches long, made of the best steel, and fitted through a small wooden cylinder, as represented in the sketch. The boring-stick (*fig.* 2.)

Fig. 2.



is a hazel wand about thirty inches in length, upon which a twisted white leather thong is fastened sufficiently slack to admit of being once twisted round the box of the piercer: the breast-plate (*fig.* 3.) is a shield of iron, with a little steel boss in the centre, and straps

Fig. 3.



attached to fasten it over the workman's belly. It will readily be seen that, by putting the wooden pulley of the piercer into the coil of the boring-band, placing its obtuse end into one of the little holes of the breast-plate boss, and its sharp end against the substance to be perforated, and then working the stick backwards and forwards, a hole is presently made of the exact size required for the insertion of rivets in the scales, and the pin upon which the blade works at the joint. Besides these tools, a hammer, saw, files of many sorts, a small anvil on the work bench, and a *snap-dragon* are required. This last instrument is a sort of screw nippers (*fig.* 4.) placed in an ordi-

Fig. 4.

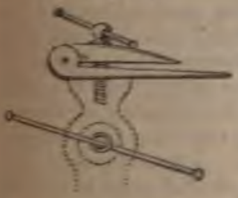
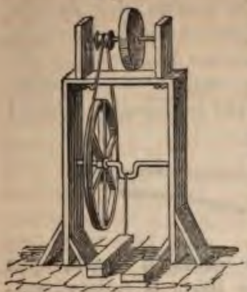


Fig. 5.



nary vice, and opening horizontally to hold a horn or other scale while being flat filed; last of all may be mentioned a frame with wheel and treddle for the insertion of buffs and glaziers upon which the various parts are finished; those of steel with emery, and those of horn or shell with sand and rotten stone (*fig.* 5.). These tools are common to the workshops of every class of cutlers.

The circumstance of these tools being so few, simple, independent, and inexpensive, has led to results in the Sheffield trade of a very peculiar and frequently harassing nature. The common arrangement between masters and workmen during the early and comparatively unfluctuating periods of the cutlery manufacture was, that the former found shop-room, tools, every description of materials, and, of course, such capital as was necessary to carry on business, paying the latter for work done generally by the piece. During this state of things, almost all dealings in the raw material and finished article were conducted between the master manufacturer and those who visited the town for the purpose of buying his wares, or with the merchant to whom consignments were made for exportation. Later years, however, witnessed the springing up of a large and influential class of monied or speculative individuals, who, under the denomination of *factors*, took advantage of the fluctuation of the markets to collect goods and merchandise at a cheap rate, never purchasing at the regular prices when they could avoid it. These enterprising dealers presently obtained large influence in the foreign markets, and, catching the full spirit of modern competition, they soon distanced the tradesmen of the old school. The latter, indeed, frequently became, through necessity, first satellites, and then victims to the new system. While trade flourished, and wages remained unimpaired, the workmen experienced little inconvenience from this change of system. But when seasons of commercial stagnation succeeded one another, as unhappily they have done of late years, a new order of things ensued. For a time the regular manufacturers stocked their goods, and paid the usual wages to their workmen, or, what was not unusual, stinted them as to the amount of work to be done, and at the same time advanced to them money on account to a very considerable amount, the workmen often owing from ten to fifty pounds. At length, however, they suffered severely; many were finally ruined; and the operatives, pressed between reduced prices and want of work, betook themselves to the *factors*. The factor, in the first place, advanced to the workman a small sum to purchase the requisite tools, and then furnished materials to be made up into finished articles, on terms often inferior to mere workman's wages.

The evils resulting from this state of subjugation and servility were manifold. It speedily caused a vast overproduction of cheap and worthless wares, and utterly destroyed the mutual good feeling of the master and workman which had theretofore subsisted very strikingly in Sheffield. The crowning evil of this new order of things was, that the greater part of the small price stipulated for finished goods was often paid to the poor artisan not in cash but in "stuff," as it was significantly called; and the factor's warehouse was the store whence food and raiment were exchanged with the poor cutler for his labour on such terms as the factor chose to impose. Thus it was, that, literally, so soon as an individual ceased to be able to obtain a livelihood as a workman he set up as a master, his manufactory being a garret or corner of his dwelling, or oftener one of the many shops let out for that purpose in the town and neighbourhood of Sheffield. Such was the prevalence of this system, that about the year 1819 most of the cutlery wares manufactured in the place were collected from these "little masters," as they were expressively termed. It may, perhaps, be some palliation of this system to add some "little masters" have subsequently, by their industry and enterprise, acquired property and respectability, the more honourable to the possessors, when we recollect the difficulties through which they were obtained.

To describe the process of making a knife of any description would be as useless and unentertaining as it would be tedious, if not unintelligible. It may suffice to mention generally, that table knives, — the blades forged, hardened, and ground, as previously described, — are hafted with materials of every description, from stamped gold or silver down to common dyed wood, or the very cheapest cast-iron. When the handles consist of sides, nailed upon a flat piece of iron, continued from the blade, as is the case in the large class of common articles hafted with that useful substance white bone, they are called *scale tangs*. This method is, above all others, the best for use, as the knife rarely separates from the handle. Another common method of hafting table knives is by the insertion of that portion of the blade which has been properly drawn out, quite through the handle up against the shoulder, and riveting it at the opposite end,—this is called *through-tang*, and admits the attainment of great firmness. But the most common course, and especially in the finer sorts, is to fasten the blade into the handle by means of melted resin mixed with fine ashes from the grate. In this manner all blades are fastened where there is no appearance of pins or rivets, and including the whole series of ivory handled knives.

A few years since an ingenious manufacturer of the name of Brownhill added an improvement which is now universal in the fabrication of what are called *balance knives:* it is effected by perforating the haft considerably deeper than is required for the reception of the tang of the blade, and inserting therein a small piece of lead, the blade at the same time being made with a projecting shoulder near the handle. By this simple contrivance, the knife, when laid upon the table, rests upon the handle and the shoulder, the blade never touching the cloth, as in common knives.

The consumption of ivory in this branch of the cutlery business is immense, including, as well the finest transparent teeth as the ordinary sorts; and it must be admitted that the beauty, durability, and comparative cheapness of the material, when so used, may well recommend it to those respectable tables where silver is not always used. Handles made of animals' horns or hoofs, dyed black, and pressed in figured dies, are largely used; so are also what are called self-tips, a variety of the horn in its natural state: this latter material, when buffed to the high polish of which it is susceptible, looks very well, but it is liable to injury from being dipped into hot water, which, as in the article of pressed horn, causes the grain to rise, and completely mars its beauty.

Besides the knives commonly used at table, there are others manufactured to a large extent as branches of the general trade, especially shoemakers' knives and bread knives; these have generally common turned light wood handles, more attention being paid to the temper of the blade than to the beauty of the haft. Of these, as well as of table knives in general, an amazing export trade is carried on from this country to the East and West Indies, and especially to America. Large quantities of plantation knives, of the commonest description, are manufactured on the Continent under the appellation of Dutch knives. In the years 1812, 1813, 1814, until the peace opened the trade with Holland, thousands of casks, full of these "Malay knives," with lignum-vitæ handles and cast-iron blades, were made at Sheffield, where the workmen called them *tormentors*, from an idea that they were intended for dirks and scalping knives.

In the fabrication of pen and pocket knives, a still greater variety of substances are used for the handles, and a much wider scope afforded for the exercise of ingenuity, than in the manufacture of table-knives. The varieties of shape are even more numerous than the materials with which the handles are covered; and hence the trade abounds with phrases and terms which have not yet found their way into any techniological dictionary.

The materials used for making the handles, besides comprising all that are adapted for table-knives in general, include also, not only some rare and curious kinds of woods, but more especially stag-horn, tortoise-shell, and mother of pearl. The stag scales consist, as is well known, of the exterior of the antler in its natural state: this substance has ever been highly prized, and, therefore, it is no wonder that modern ingenuity has found out a method of imitating its fine colour and curiously corrugated surface on an inferior material. The tortoise-shell, when buffed to a high polish, its dark and transparent colours properly mingled, and placed over a foil of orsidue to give a yellow lustre to the lighter part, is a rich and curious mounting. Pearl scales, either with or without carving and engraving, are much in request for their beauty, though more liable to suffer from accidents than any other material.

The knife is produced in accordance with any one of the almost innumerable varieties of form known in the trade, by filing both the sides to the exact shape of a hardened steel-plate, which is likewise perforated in the proper places as a guide for the piercer. The blade, spring, and scales, being severally bored, the whole is pinned together, loosely at first, till all the parts being exactly fitted, the knife is found to work properly — with bits of wire, rivetted with a hammer on the little anvil on the work bench. The sides, if of horn, ivory, or shell, are then filed smooth and scraped, after which they are submitted to the buff, which is a trundle of wood covered with thick soft leather, and made to revolve rapidly by means of a wheel and pulley, *fig.* 5. The dressing laid upon this buff is first a coating of fine Trent sand, mixed with oil; this is succeeded by a coat of pulverised rotten stone, after which the finer scales are polished by the hand with rotten stone-dust and oil.

It is not uncommon to insert a small shield, either of silver or some other metal, in one of the sides of a penknife: the process of making the little cavity for the reception of this shield is curious: the workman takes what he calls a *spring piercer*, a tool similar to that already described in its general form; but, instead of the straight flattened point, consisting of two somewhat elastic steel blades, equal in length, and appropriately sharpened at the ends, *fig.* 6. These he inserts through a small plate of steel perforated according to the required shape of the shield, *fig.* 7., and placed upon the scale; then applying the boring stick, to give revolution to these prongs, a cell is ground out exactly of the shape and size required, and generally of one or other of the figures represented in the annexed cut.

Fig. 6.

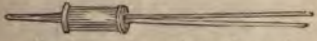
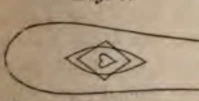


Fig. 7.



The *piece*-knives, or *sportsman's knives*, as those complex articles containing saws, lancets, phlemes, gun-screw, punches, large and small blades, &c. used to be called, and which were manufactured rather for curiosity than use, being generally too heavy for the pocket, have been latterly superseded as tests of superior workmanship, by what are denominated *lobster* knives, invented by Mr. Crawshaw. The chief peculiarity of principle in the fabrication of these latter articles, consists in slitting a small piece of steel with a saw at both ends, and placing it inside along the middle of the knife, instead of making it form the back as is usually done, and by this contrivance obtaining springs for the working of four blades instead of one. The tang, or that part of the blade which works upon the spring, is likewise rounded at the corners, instead of being left square, as in the old knives; by this alteration the knife is made to open and shut much more easily and smoothly than by the common method. It is chiefly these principles, so admirable in the construction of a light, elegant, and useful knife with four or eight blades, that have been applied in the production of those absurd and useless masses of fine materials and superior workmanship, called "knives with hundreds of blades." One of the most superb specimens of this complication cutlery ever produced, is undoubtedly the knife exhibited under a glass cover in the show-room of Messrs. Rodgers, the well-known cutlers in Sheffield, and by them at the Great Exhibition.

A good penknife is an article of such indispensable utility with almost every gentleman and lady, and more or less so with almost every individual in civilised society, that it is no wonder that uncommon pains should have been taken, and various methods adopted, for the attainment of perfection in its manufacture. Something, of course, depends upon the size and form of a handle: if this be too large, the knife will be clumsy and unmanageable; while, on the other hand, if it be too small, the user will want that proper command of the blade which is essential in the dexterous and successful cutting of a quill. In general, a handle rather fuller in the hand than those of most of the fancy knives, will be found preferable for use to one of those slender shapes that are so elegantly got up, rather for the purpose of nibbing a pen occasionally, than for service and durability at the desk or the writing-table.

The blade, however, as every one knows, is of main importance; and therefore very great perfection has, in many instances, been attained in all the processes connected with the making of it. The very best cast steel ought always and alone to be used in the manufacture of the blades of fine penknives; and the forging, hardening and tempering, grinding, and whetting, are operations that require, severally, that nicety of management, which is in general rather sought and secured by long practice of good workmen, than performed according to any specific theory.

The outline of the blade is chiefly a matter of fancy; only if it be too broad it will not effect that graceful curve from the shoulder to the point of a pen which a *fine quill-cutter* seeks to produce; and if it be too narrow, its operation on a fine proud quill will be jagged and indirect, remote from that freedom of slicing and preciseness of formation so indicative of a good blade and a good hand.

To obtain a blade, which shall unite with the greatest keenness of edge the utmost freedom of operation in the using, is a desideratum; for though an ordinary shape, when the material is first-rate and the workmanship perfect, may in general perform satisfactorily enough, yet it is manifest that, strictly speaking, the line traversed by a perfectly flat-sided blade in the making of a pen is not in accordance with the mechanical direction of the edge. This will be obvious, by inspecting for a moment the sketch, *fig.* 8. in which the sides of a pen are indicated by the segment of a circle from A to B, while the direction of a straight-edged blade is shown to be from C to D. To meet this obvious peculiarity, blades have been ground convex on the under, and concave on the upper side, by this means acquiring a line of direction from E to F, or parallel with the section required. The advantages which this mode of grinding theoretically presents, are found to be practically set aside by the accessary course of whetting,—and this, in the first instance,—much more by repeated courses. This will be apparent, when it is recollected that the application of the edge on the concave or *mark* side upon the stone must be at the best in a right line with the back, *i.e.* from G to H, *fig.* 9., while the line of whetting on the convex or *pile* side will be from I to K, the angle of the cutting part being in reality of the degree of obtuseness indicated by the crossing of the dotted lines. In the common description of blade, which exhibits simply a section, in

Fig. 8.

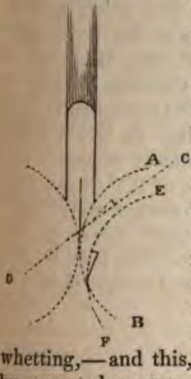
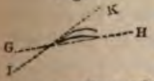
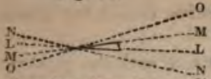


Fig. 9.



the form of a wedge, more or less acute, as in *fig.* 10., L L M M; the process of whetting, differing, however, as it does in different hands, is generally to elevate the back a little from the stone, thereby forming a slight angle with the surface, as N N O O.

Fig. 10.



To obtain this angle as acute as may be compatible with extreme and durable keenness, the blade has been ground slightly concave on *both* sides, the back at the same time being considerably thinner than usual; so that in whetting, the back of the blade, instead of being elevated from the stone, as in *figs.* 9. 10., is placed *upon* the stone at the same time with the edge, thus furnishing an infallible criterion for whetting even in the most inexperienced hands. The acuteness of the cutting angle of this last-mentioned blade is shown by the lines P P Q Q in the magnified section, *fig.* 11. This blade having in fact a razor edge, is found to cut with the utmost sweetness and ease, especially when the curvature of the nib is inconsiderable; and, to use the words of the inventor, "even by inexperienced hands, may be easily governed. No cutting but what is intended can take place; and the pen is formed with the greatest nicety and utmost facility."

Fig. 11.

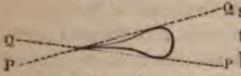


Table Forks.

Forks, although now used at our tables as commonly as knives for the division of the food upon our plates, and for transferring it to the mouth, were of much more recent introduction, and are, indeed, comparatively of modern invention. As the office of carver (*carptor*) is of great antiquity, and as such officer would probably be the first to experience the necessity of a fork, so it may be presumed that the first attempt to fabricate such an implement, of metal at least, would originate in the suggestions of his art. The oldest instrument of this kind known, however, is said to have been for individual convenience, having been formerly used by Henry IV. of France, and is still preserved at the castle of Pau. It is of steel, two-pronged, and of length and strength sufficient to secure a baron of beef.

Forks were unknown to the ancient Greeks and Romans, and to all other nations, unless, indeed, the little polished sticks of ivory used by the Chinese for the purpose of feeding themselves may be considered as an exception. These "chop-sticks," however, as they are called in India, are not always pointed, but rather in the shape of an ordinary uncut cedar-wood pencil, and are used in pairs, one in each hand, with great dexterity, — seldomer, however, in picking up morsels from the plate, than for the purpose of shovelling the contents of the plate directly into the mouth; such mode of feeding not being considered contrary to decorum among the inhabitants of the celestial empire.

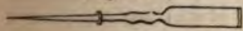
According to professor Beckmann, forks were probably brought into use by the Italians, about the end of the fifteenth century. At what time they were first introduced into this country does not clearly appear: the earliest mention of them occurs in a curious passage of Coryates' "Crudites," a singular book of travels published in 1611. The author says, "Here I will mention a thing that might have been spoken of before in the discourse of the first Italian towns. I observed a custom in all these Italian cities and towns through which I passed, that is not used in any other country that I saw in my travels, neither do I think that any other nation of Christendom doth use it, but only Italy. The Italians, and also most strangers that are cormorant in Italy, do always, at their meals, use a little fork when they cut their meat. For while with their knife, which they hold with one hand, they cut the meat out of the dish, they fasten their forks, which they hold in their other hand, upon the same dish; so that whatsoever he be that, sitting in the company of any others at meals, should unadvisedly touch the dish of meat with his fingers from which all the table do cut, he will give occasion of offence unto the company, as having transgressed the laws of good manners, insomuch as that for his error he shall be at least brow-beaten, if not reprehended in words. This form of feeding, I understand, is generally used in all places of Italy; their forkes being for the most part made of iron or steele, and some of silver, but those are used only by gentlemen. The reason of this their curiosity is, because the Italian cannot by any means endure to have his dish touched with fingers, seeing all men's fingers are not alike clean. Hereupon I myself thought good to imitate the Italian fashion by the forked cutting of meat; not only while I was in Italy, but also in Germany, and oftentimes in England since I came home, being once quipped for that frequent using of my forke by a certain learned gentleman, a familiar friend of mine, one Mr. Laurence Whittaker, who, in his merry humour, doubted not to call me at table *furcifer*, only for using a forke at feeding, but for no other cause."

It would almost seem, from the foregoing passage, that for each guest to put his fingers into the dish was no "curiosity" 250 years since, even among "travelled gentlemen:" indeed, Dr. Johnson asserts that among the Scotch highlanders, not only forks, but even knives, have been introduced at table since the period of the revolution. Before that period every man had a knife of his own as a companion to his dirk or dagger. The men cut the meat into small morsels for the women, who then put them into their mouths with their fingers. The use of forks at table was at first considered as a superfluous luxury; and, therefore, they were forbidden to convents, as was the case in regard to the congregation of St. Maur.

Forks, although generally made along with table knives, are considered a separate branch of manufacture. They were, formerly, all wrought at the anvil, and rarely, except when made of silver, consisting of more than two prongs. The formation of these, however, by the hammer, was not only a tedious and expensive process, but likewise required a better sort of metal to admit of being so drawn out. At present, however, iron, steel, hammer, and anvil, are dispensed with altogether in the manufacture of the cheapest sorts: the casting-box and common pig metal being substituted, thousands of grosses of this comparatively worthless description are made to accompany knives not altogether of so bad a character. A large proportion, however, of the forks furnished with the better kinds of table knives, are cast of the rich Cumberland metal elsewhere mentioned; and, by being submitted to the annealing process already described, may be brought almost to any degree of toughness and rigidity. They admit of such a polish as to pass with all but the most practised eyes for the best steel, while at the same time they are sold at very moderate prices. Indeed, the application of the casting process tends to facilitate amazingly the manufacture, and to diminish the cost of a large class of these articles, especially the *spoon forks*, as those articles derived from the French, and furnished with four or five prongs, are denominated. These latter are for the most part for the markets abroad, foreigners still using the fork at table much more extensively than we in general do.

The manufacture of the best steel forks has latterly been accelerated and improved by an invention of very obvious utility. The fork is reduced, as usual, from the rod of steel at the anvil into something of the following shape: — the tang, shoulder, and shank being roughly forged, and the *blade*, as it is called, left thick and whole. In this state it is called, in common with all articles after the first formation by the hammer, a *mood* (mould): it is then taken and *stamped*, in which operation it is first heated till sufficiently soft, and in this red hot state is next placed in a cut steel boss or die, upon which another boss, exactly adapted, is made to fall in connection with a heavy block of metal, which for this purpose is drawn up and suffered

Fig. 12.



suddenly to descend by means of a rope and pulley, in a manner very similar to that hereafter described in the article on silver-plate working. Thus, at a single stroke, the prongs and the bosom, or contour of the instrument, are completely formed, after which it is ready for the filer, generally a female, who clears out the spaces between the prongs; and, subsequently, the grinder and burnisher perform their parts. As all forks are ground on a dry stone, the workmen are more especially liable to that dreadful disorder which destroys so many of them in early life, and which is occasioned, as before stated, by their inspiration of the fine metallic and other particles that are constantly evolved by the operation of the grindstone. It can hardly be necessary to add, that forks are hafted in the same manner, and with the same variety of materials, as table knives.

An ingenious, and almost inseparable adjunct of the modern carving-fork, is a small spur working upon a spring in a swell of the shank, and capable of being thrown up in a right angle with the instrument, so as to protect the hand against any slip of the knife during carving. Instead of this *guard*, as it is universally called, Messrs. Rodgers of Sheffield have a patent for affixing to forks two bits of steel cut like a file, and ready to be used by way of a sharpener to the knife. As substitutes for the common steel, which, however elegantly manufactured, certainly is not very eligible to use at table, an extensive variety of contrivances, under the appellation of *knife sharpeners*, have latterly obtained considerable vogue. They have all been suggested by the instrument for which Mr. Felton obtained a patent, and which consisted in fixing two channelled rollers of steel in a neat frame. Many of these inventions display ingenuity, and all of them great beauty of workmanship: they appear, however, to be hastening into disuse even more rapidly than they came into notice. The disagreeable sensation produced upon the nerves of most persons by the harsh grating of *steel versus steel*, constituting an insuperable bar against their ultimate adoption.

CHAP. II.

RAZORS.—LONDON BRIDGE METAL.—RHODES.—GRINDING AND POLISHING.—KINGSBURY.—FORM AND THICKNESS OF BLADES. FRAME-BLADED. — STAINING OF HANDLES. — ORNAMENTING BLADES. — KNIGHT'S STEEL SHARPENER.—SURGICAL INSTRUMENTS. — SCISSORS AND SHEARS. — SNUFFERS.

THERE is no description of cutlery in the manufacture of which the attainment of perfection is so difficult, and yet so indispensable, as in the article of razors. For this reason hardly any price is thought too high for a good razor, while a bad one is worse than useless. A person may contrive to make a pen with a bad knife, or eat a good dinner, however indifferent the table cutlery may be; but the daily misery of smarting under the infliction of an indifferent razor, is a trial to which few can patiently submit. Yet the assertion, that there are more bad razors than good ones, will hardly come with the force of novelty to the knowledge or the experience of many persons. Although it is a fact that razors, with blades cast of pig-metal, have been made "to sell," the number of these detestable scrapers, that find their way into the market now-a-days, bear no comparison with the quantities that are made of bad steel, still more badly managed in the workmanship.

As might be expected in an article of such universal necessity among all classes from the peer to the peasant in our own country, as well as of such large demand in the foreign market, considerable attention has, of late years, been paid to the manufacture and the whetting, or, as it is technically denominated, the *setting* of razors; and the public have been made acquainted with the subject by means of three or four ingenious pamphlets, which, within a few years, have been published by individuals more or less qualified for the task.

In the process of manufacture the blade of a razor is, in the first instance, formed upon the anvil from a bar of the very best highly carbonated cast steel, much in the same manner as that already described in connection with the fabrication of other descriptions of cutlery. The blade, properly so called, is first moulded or shaped by the hammer upon the rod of steel, the edge being brought out, and the concavity formed by working the material on the rounded edge of the anvil: it is then chopped off; the tang or tongue, by which it is fastened into the handle, is drawn out; it is lastly smithed and hardened. As there is generally such a large disproportion between the thickness of the back and the edge, the steel ought to be of an excellent quality in order to allow of the beating necessary to produce the thinner part. Some workmen are so expert in accomplishing this, that they will produce on the anvil an edge so sharp and even, that whetting alone will be required to prepare the blade for the purpose of actual shaving. The performance of this feat, however, furnishes an indubitable proof that the material so operated upon is necessarily otherwise than sufficiently malleable, because a blade of pure soft iron may be so forged and whetted as that it will for once remove an ordinary beard with considerable facility. Whatever effect may be produced upon steel by decarbonisation through the process of rusting in the air or under ground, a belief in the value of some such process for improving the material of cutting instruments is generally entertained, and sometimes turned to curious account. On the removal of old London Bridge, it was stated, that the wrought iron with which the piles were shod was found to be of such fine quality, and so malleable, that some tons of it were contracted for by Weiss, the cutler, for converting into steel, — the action of the moist clay, without exposure to the air, having had such an effect upon the metal as to render it almost equal to steel.

"So," said one of the metropolitan journalists, "we may one day mow our beards with a relic of old London Bridge."

"To what strange uses may we not return!"

In the forging of razors, as in all cutting instruments, it is of importance that the article be well *smithed*, or hammered after it has become cool, in order that the pores may be closed, and the structure be rendered as compact as possible. The shape, or profile, of the blade is variously formed, to meet the different tastes or prejudices of purchasers, — some preferring it quite straight on the edge, others convex; many broader at the heel than at the end, or *vice versâ*. This variety, although not unworthy of attention, is of small importance compared with the more essential qualities of prime material and perfect temper.

The processes of hardening and tempering razor-blades require to be conducted with the utmost nicety; and hence the numerous failures. To secure success in ordinary manufacture, the course already noticed has been recommended, viz. instead of hardening the blade directly from the anvil, which is the usual practice, that it should be intermediately passed from the forger to the grinder, in order that the latter, by a slight application of the stone, may remove that scale, or coating, which prevents the uniform application of the water and heat in hardening and tempering. On account of the additional trouble and expense, this course is rarely adopted, even in cases where the ultimate price of the article is considerable.

The blades are then carried to the grinding-wheel, where they not only receive that proper and uniform concavity of surface which is one of their essential qualities, but that exquisite polish, which, without in the slightest degree improving the quality of the instrument, too often, by the manner in which it is communicated, deprives it of an essential property, which no subsequent operation can restore. Mr. Ebenezer Rhodes, of Sheffield, whose practical knowledge of the nature and working of steel cannot be doubted, says, in his "Essay on the Manufacture of a Razor," "*Form, weight,* and *justness of proportion,* united with a proper degree of *hardness,* are certainly constituent parts of a good razor; yet its excellency depends likewise on its possessing a *regularity* and *fitness* of *concavity.* It is already almost generally known that this quality is produced by the stone, in the process of grinding, and by the use of stones of different diameters, varying from *four* to *twelve* inches, according to the price of the article required: and it cannot have escaped observation, that this alone constitutes a very essential difference of edge.

"The grinding of razor-blades on a four-inch stone has recently so much prevailed, that a few remarks on its superior pretensions may be admitted with propriety: — It is easily discernible, that a razor thus manufactured must of necessity possess great thinness of edge; a circumstance which, independent of any other, renders it unfit for general purposes, even though it may be used in some cases with advantage. A strong wiry beard will put all its boasted excellence to the proof: here it will be found that a less degree of concavity, and, of consequence, a bolder and firmer edge, is indispensably necessary. From the observations here adduced, it appears, that the concavity of the blade should at all times be regulated by the formidableness of the object it has to encounter. Razors, however, ground upon stones of from *six* to *eight* inches diameter, or thereabouts, may be recommended as best adapted for general use; they are sufficiently hollowed, or ground out for any service, however hard, to which they may be applied; and they combine a desirable strength and firmness of edge, with a requisite degree of thinness. The concavity of a razor should likewise possess great evenness and regularity, otherwise a very unequal edge is produced; a defect which every application to the hone will rather increase than diminish, and which nothing but re-grinding in a more perfect manner can possibly remove."

The blade being properly ground, is then *glazed*, as the workmen call the operation of smoothing after the stone, by applying it to the *lap*. This lap is a trundle of wood, upon the edge of which is attached a rim of alloy, consisting of lead and tin: the surface of this metal is covered with flour emery, and it revolves with the rapidity of 1500 feet in a second. From the glazier, the blade is transferred to the buff, or polisher, which is a solid wheel, differing from the glazier, chiefly in that it is covered with thick soft leather, dressed with crocus marti, and runs much slower than the lap, or even the grinding stone, generally about eighty feet in a second. Its operation produces that rich black lustre so peculiar to fine steel wares. In the process of glazing, a stream of sparks is produced; and the rapid motion of the surface of the lap or glazier evolves a considerable degree of heat, sometimes sufficient to *blue* the article. The temper of a blade is, in this case, likely to be affected, and this more especially with an instrument having a thick back and thin edge, like a razor. Against this there is no preservative beyond that extreme care, on the part of the workman, which either insufficient remuneration or indifference too seldom allows him to bestow.

A blade thus spoiled admits of no restoration by whetting or otherwise; nor can the purchaser discover by any test, short of actual use, whether a razor blade have this defect, or another hardly less common, *viz.* having been *burnt*, that is, overheated in the hardening, and therefore incapable of receiving a keen edge. Mr. Kingsbury, formerly a celebrated *setter*, or whetter of razors in the metropolis, in his ingenious "Treatise on Razors," recommends a *magnifying-glass* as "the only satisfactory and safe manner of determining the state of its edge without using it." This must, however, be a very fallacious criterion, even in the hands of an experienced observer. Kingsbury lays much stress upon the fact, that the edge of every cutting instrument, however exquisitely entire it may appear, does in reality consist of a succession of serratures more or less minute. "Indeed," says he, "a common saw is better calculated to convey some idea of the edge of a razor, and its mode of operation, to a superficial observer, than perhaps any instrument whatever." This assertion, which is philosophically correct, must, however, be of less use in enabling any person to discover the merits or the defects of an untried razor, than as it may serve to correct the very common mistake in the mode of using it.

Grounded on this idea of a serrated edge is Mr. Kingsbury's recommendation, that the line of the blade should be as *straight* as possible. Mr. Rhodes, on the other hand, though for the very same reason, advocates a *convex* edge of considerable curvature! He says, "notwithstanding the great commendation which has been bestowed upon the straight-edged razor, by the writer of a very sensible treatise on the subject, it is by no means adapted for general use. It is, in fact, fitted only for those who, convinced that every cutting instrument, from a saw to a razor, is composed of a regular succession of teeth or points, nearer or farther apart, have learned to distinguish between the operation of cutting, and what may not inaptly be denominated scraping."

The latter, however, is the prevailing mode of shaving; it is the practice, in a greater or less degree, of almost every man who uses a razor: and as it is an evil which cannot be entirely removed, it must be partially provided against. How far this is within the power of the razor-maker will, perhaps, appear from the following remarks: —

"It may be here laid down as a principle, that whatever the form of the back of a razor may be, the edge should always describe a portion of a circle. It must be tolerably evident to every man who thinks upon the subject, and who has paid attention to the manner in which a razor is commonly used, that the blade here recommended, even if applied in the very injudicious mode above alluded to, has decidedly the advantage; passed over the face obliquely from the point to the heel, or drawn downward without the least obliquity of direction, it must of necessity cut even where a straight-edged razor would do nothing but fret or tear the skin, without removing the beard. After all, it must be admitted that the advantage which a circular or full-edged razor has over a straight one in point of cutting arises chiefly from a very defective manner of shaving; so long, however, as this defect exists, so long will the full-edged razor claim a decided superiority. It often happens that men, groaning under this very useful and necessary operation, attribute their bleedings, and writhings, and contortions of face, to the badness of the razor, when the principal fault is in themselves."

To return, however, from this digression on the use of a razor to the observations on its manufacture, it is right to say, that while a stout, efficient, and far-famed instrument, appropriately designated the "old English razor," has obtained deserved reputation, so likewise has a very light and elegant article, called a "frame bladed razor," been largely in demand. This latter razor, instead of being forged at the anvil out of the rod, is made of rolled or sheet steel of the finest quality, let into a back of copper or brass. These blades being nearly as thin at the back as at the edge, the difficulties encountered in the hardening and tempering are almost entirely obviated: for as Parkes, in his "Chemical Essays," justly observes, "when instruments have a thick back and a fine edge, it is almost impossible ever to give them an uniform temper by the old method; for there will always be a danger of the edge being lowered too much before the other become regularly heated throughout." The formation of this razor was suggested about twenty years ago by the celebrated David Hartley, Esq. M. P. for Hull. Having been made in Paris, and becoming known as the French razor, the manufacture was slightly modified, and a patent was obtained in 1823 for the term of five years by M. Boullay, cutler to the Royal Veterinary School of Alfont, for the manufacturing of razors with economy and despatch. The alacrity of the process consisted, according to the *Description des Brevets*, in the blades being cut out of sheet steel with a fly press: these were then fitted into backs of grooved wire. The inventor states, that in this way a razor may be completed in an hour; may be made of the best cast steel, and at the same time very cheap. This patent was annulled, by order of the king, two years after it had been obtained.

The handles of razors are composed of nearly every description of material ordinarily used in the hafting of table knives, but generally of horn, ivory, tortoise-shell, and rarely of pearl. The latter beautiful material is very expensive for this purpose, on account of the difficulty of obtaining the shell of sufficient size, and the care required in the working of a substance so brittle. Ivory teeth are cut into spells of the requisite size with great facility, by means of a circular saw made to revolve either by a treddle, a hand-wheel, or the agency of steam. Of the commonest kind of razors, the handles are made of horn, either dyed black and pressed in figured moulds, after the manner of the common umbrella hooks, or translucent, and stained to resemble the tortoise-shell, in the style of the combs used by the lower class of females for trussing their hair. This colouring process, which renders valuable an otherwise undesirable description of horn, is performed as follows:—

The horn which is selected for staining is semi-transparent, whether in its natural state, and reduced by the file, or pressed by means of heat in iron moulds, to the size and shape required for one side of a razor handle; by either operation, the surface having been made sufficiently smooth, the piece is, in the first instance, laid in a heated infusion of turmeric and Brazil-wood, until it assumes the yellowish tint intended as the general ground. Finely sifted quick lime, mixed with a small portion of litharge, is then made into a paste of a consistency rather stiffer than cream, with a strong lixivium either of pearl or fern ashes. This composition is then dropped upon the surface of the article to be coloured, in blotches varying in size and disposition according to the taste of the user, or rather at random, leaving the effect to chance, as may be supposed, when it is stated that as many as twelve dozens are frequently spotted in an hour. The scales, or sides, are then piled upon a board, and covered with a considerable thickness of moist cloths; after which, the whole is placed before a fire over night, in order to expose the work to the full effect of a hot, moist, vapour. In the morning, the colours are found to have penetrated, and tinged with various degrees of opacity, the substance of the horn. The composition is then removed; and the pieces, which, in consequence of the heat, lapse into all sorts of shapes, are straightened by being placed in parallel rows upon a board under weights; after which they are ready for polishing on the buff, with Trent sand, and rottenstone mixed with oil. The colouring process, when successfully managed, gives to the transparent horn an appearance resembling some of the duller kinds of tortoiseshell, and by this means renders a material which, in its natural state, is comparatively valueless, of considerable importance in adaptation to form the handles of cheap razors. The insertion of a shield of silver, or some metal not seldom mistaken for silver, is very common. Of late years very elegant handles have been got up by studding the ivory scales with gold or silver points, arranged with tasteful variety.

There is a practice of ornamenting the blades of razors, and highly polished cutlery in general, by a process which, although extremely simple, and now generally understood, was long kept a secret; and which, from the effect it is capable of producing in good hands, deserves to be regarded as one of the fine arts. The reference is to the process of *etching*, by means of a weak acid, those inscriptions, figures, and even landscapes, often so exquisitely delineated on various steel goods. There is good reason for believing that this method of operating upon steel, although comparatively of recent introduction in the cutlery trade, is by no means a modern invention. The corrosive effect of most acids upon polished steel must have attracted attention wherever the metal was in use; and the possibility of intercepting or of directing such effect by the application of some unctuous coating must equally have presented itself. The Chinese, the Arabians, indeed the Oriental nations generally, were acquainted with the various methods of ornamenting steel; and besides the descriptions which occur in different authors, relative to figures on the arms and armour of antiquity, certainly not always stamped or engraved, there have been pieces preserved to modern times the appearances of which can only be explained on the ground of the knowledge here assumed.

The art, as at present practised, consists of delineating the subject on the surface of the metal with varnish by means of a camel-hair pencil, covering likewise the edge and such other parts as are to remain bright with a similar coating. The article thus prepared is dipped into a vessel of dilute nitric acid, and subsequently washed in water. The varnish is then cleared off by the application of spirit of turpentine; and it will be found that the exposed parts, having been very slightly corroded by the menstruum, will present a dull appearance, while the defended portions retain their original polish,—thus, by contrast, forming a very pleasant species of delineation. The effect is reversed by covering the article entirely with varnish, and then working through it with a point in the manner practised on plates for printing, and afterwards biting in the work with the acid. By this process the figures may be either slightly delineated or deeply etched into the substance of the article, while the circumjacent parts, on the removal of the varnish, retain their fine polish uninjured.

The manner in which, according to the scriptural expression, "iron sharpeneth iron" has long been exemplified in the ordinary method of giving an edge to knives used at table; the idea, however, of whetting a razor upon a steel, appeared but remotely to stand connected with such an operation. The experiment, nevertheless, has not only been attempted, but executed with success by a gentleman named Knight, who was president of the Horticultural Society of London. The journal of the Royal Institution contained the following account of the contrivance of Mr. Knight:—The instrument consists of a cylindrical bar of cast steel, three inches long without its handle, and about one third of an inch in diameter. It is rendered as smooth as it can be made with sand, or more properly glass paper, applied longitudinally, and it is then made perfectly hard. Before it is used it must be well cleaned, but not brightly polished; and its surface must be smeared over with a mixture of oil and the charcoal ot wheat straw, which necessarily contains much silicious earth in a very finely reduced state. "In setting a razor," observes Mr. K., "it is my practice to bring its edge, which must not have been previously rounded by the operation of a strop, into contact with the surface of the bar at a greater or less, but always at a very acute angle, by raising the back of the razor, more or less, proportionate to the strength which I wish to give to the edge; and I move the razor in a succession of small circles from heel to point, and back again, without any more pressure than the weight of the blade gives, till my object is obtained. If the razor has been properly ground and prepared, a very fine edge will be given in a few seconds; and it may be renewed again, during a very long period, wholly by the same means.

"I have had the same razor, by way of experiment, in constant use during more than two years and a half; and no visible portion of its metal has within that period been worn away, though the edge has remained as keen as I conceive possible; but I have never, at any one time, spent a quarter of a minute in setting it. The excessive smoothness of the edge of razors thus set led me to fear that it would be indolent, comparatively with the serrated edge given by the strop; but this has not in any degree occurred, and, therefore, I conceive it to be of a kind admirably adapted for surgical purposes, particularly as any requisite degree of strength may be given with great precision." Experience, however, has not shown that this article is likely to supersede the whetstone and strop, for the sharpening of razors. or surgeons' instruments.

Surgical Instruments.

Properly considered as a branch of cutlery, and nearly akin to razor-making, is the manufacture of surgical instruments in all that endless variety of adaptation and finish which modern science has suggested. In the formation of several of these articles considerable ingenuity is displayed, accompanied, in general, by the most exquisite workmanship. Though these instruments are in most cases sold by the fine hardware dealers in the metropolis and elsewhere, the making of them is a distinct branch of trade. In London, Weiss, and in Sheffield, Cluley, are celebrated. It would be easy to give figures and descriptions of upwards of 100 varieties of these admirable instruments, to the diversity and perfection of which, in connection with professional dexterity, the alleviation of human misery is so amazingly indebted; but as such a catalogue would not be in place here, this general allusion to the subject must suffice. It need hardly be asserted that, in the manufacture of surgeons' instruments especially, the very best steel that can be obtained should be exclusively used; and this will appear no less manifest whether we have reference to strength and elasticity of the material, or its susceptibility of receiving and retaining an exquisite edge. And yet even these important articles, upon which the successful performance of so many nice surgical operations depend, are sometimes made *to sell* rather than to cut. The only security of which the practitioner can in general avail himself in the selection of his instruments, is to purchase them from some maker of reputation. Cheaper and, consequently, indifferent instruments are usually sought by needy and inferior surgeons; and, as the number of the latter is unhappily not small, the temptation to manufacture worthless lancets, and scalpels, and saws, is also considerable. It is bad enough to suffer under the hands of bungling chirurgeons, without being compelled to endure the additional torture of blunt or ill-manufactured instruments.*

Scissors and Shears.

Scissors are an article, the ultimate commercial value of which depends more upon the amount of workmanship consumed in their manufacture, than any other description of cutlery: for, however at first sight a pair of plain scissors may seem to present but a barren field for the exercise of ingenuity, even a cursory examination of the immense variety of shapes, modes of ornamenting and getting up, will lead to a contrary conviction. The blades are, indeed, in the majority of sorts, pretty similar in their general outline, it being mainly upon the bows and shanks that the labour and ingenuity of the workmen are expended. With such a diversity of patterns, it will not be surprising that the scissor-makers' vocabulary is rich in appropriate phrases. To enumerate and explain these terms, useful as they are in the trade, would afford little information and less amusement to the general reader: it may, therefore, suffice to remark that *dog-leg*, *quaker*, *tup*, *bat*, and *pillar-shank*, are, as it were, the five senses of the scissor-makers' craft. The difference in the quality of scissors is almost equal to their diversity of shape; a single pair of show scissors having been invoiced at ten guineas, while vast quantities are manufactured for the markets of South America and the East Indies at so low a price as threepence halfpenny per dozen!

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* The Egyptians formerly contented themselves with using an Ethiopic stone in opening bodies for embalming. The ancient Peruvians, as well as the Africans, are said to have opened a vein with a sharp flint as dexterously as a modern operator would with a lancet.

At home, however, we hear fewer complaints of the badness of scissors than of almost any other class of cutting instruments; and this, perhaps, chiefly for the reason, that a pair of ordinarily good ones may be purchased for a trifle: and, besides, as common scissors do not admit of being whetted by the parties using them, their chances of injury by mismanagement in this respect are proportionally reduced.

The following are the general varieties of scissors, as regards the quality of the material:—

1. Cast steel polished scissors.—These are hardened in the blades, shanks, and bows, and comprise the finest sorts. As these elegant articles are generally used by the fair sex, it may not be improper to observe, that to one of themselves is attributed the distinction of having inspired the happy idea of *hard polishing*, which has been the source of so much subsequent improvement and profit in the trade. About the year 1760, Mr. Robert Hinchliffe, of Sheffield, setting at nought the threadbare adage, that "given scissors cut love," and wishing to produce an article very superior in appearance to any then in use, as a present to a favourite young lady, had the honour of making the first pair of scissors *hard polished;* which valuable improvement has, ever since that time, been adopted by all manufacturers.

2. Shear steel scissors;—the blades only of which are hardened: the greater part of the scissors in common use are of this description.

3. Shot scissors;—consisting of steel blades, and iron shank and bows. Large scissors, in general, including tailors' shears, and those used in dressing horses, are thus manufactured.

4. Lined blades.—Scissors of all the larger sizes are often made entirely of iron, with the exception of a slip

of steel welded along the edge of the blade; the reduced value of common steel on the one hand, and the cheapness of the material next mentioned on the other, have materially lessened the demand for this article.

5. Run, or virgin steel; — which, indeed, in the proper sense of the term, is no steel at all, but rather good cast metal, the Cumberland produce before described.

6. Common cast iron. — So prodigious has been the demand for cast scissors, and so largely has the sand-box superseded the anvil in this manufacture of late years, that where there used to be 300 or 400 scissor forgers there are, at present, hardly more than fifty.

7. Besides the foregoing varieties, may be mentioned the fancy scissors with shanks and bows of gold, silver, pearl, and likewise those that are ingeniously implicated with the fabrication of some descriptions of penknife.

The following enumeration of the processes through which a pair of polished scissors, sold at the shops for about half-a-crown, generally pass, will convey a tolerable idea of the ordinary course of manufacture. The blade is forged at the anvil out of a bar of steel of the proper size, from which it is presently cut with a chisel, along with so much of the metal as will be required for the formation of the shank and bow. A hole is then punched through the *mould*, as the rough blade is called, sufficient to admit the point of a little beaked anvil, called a *beck-iron*, and placed on the stithy. Upon this the bow is formed by a process of hammering, the tediousness of which is occasionally much aggravated by the tendency to break open, which bad steel exhibits when so elaborately wrought from the fire. The article being thus fashioned so far with the hammer, is, in the next place, put into the fire in little bundles to be *lighted* or softened. It is then taken to the filer, by whom the shank and bows are more perfectly

Fig. 13.

fashioned, and the joint squared: he likewise bores the pin hole and fits it for the reception of the screw. In this state the scissors first go to the grinder, who shapes the blades on the stone; an operation requiring peculiar dexterity on the part of the workman, in consequence of that nice flexure of surface which every scissor blade exhibits. They are then put into the hands of women, and by them the bows, the beaded and otherwise ornamental work, are smooth-filed and rough-burnished, or got up by means of a stick with fine emery and oil. Being returned to the workboard, they are put together by insertion of a screw, and made, as the workmen term it, to *walk* and *talk* well; that is, by so setting the blades that they shall move more smoothly against one another. In this state they are wrapped from the point upwards to the bows with fine iron wire, the screw is taken out, and the blades and shanks are hardened by the usual process. When stripped of the wire they are again sent to the grinder, from whom they now receive their perfect shape; are returned to the workman, who inserts the screw, and makes the scissors to fit, work and cut perfectly; indeed they are never better for use than after this last operation. The bows and other parts, having become black during the hardening, are again rubbed bright by means of fine flour emery, and oil; and the scissors are sent, for the third time, to the grinding wheel, where the shanks are ground as they may require it, and the whole glazed and polished as perfectly as possible. The putter together having finished and inserted the screw, and whetted the edges of the blades, his work is done, and the scissors are finally got up by women, who carefully fine-burnish the bows with a polished steel instrument adapted for the purpose.

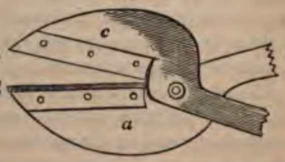
For several years past fashion has led to the manufacture to a large extent of ladies' and fancy scissors, the shanks of which have been composed of rich open work, executed in such a manner as necessarily to enhance considerably the expensiveness of the article, which, however, is extremely elegant when well finished: to this has latterly succeeded the ornamenting of the shanks with embossed figures, which are in some instances admirably executed. Some of the filigree shank scissors at present in fashion are wrought with incredible labour and ingenuity, often occupying an industrious workman two or three weeks in boring and filing out the design upon a single pair.

These fanciful articles are highly esteemed in France, the artists of which country themselves get up superb designs in pearl for scissor shanks. Sheffield, however, stands unrivalled throughout the world for the manufacture of fine scissors; those accompanying all the most expensive collections of surgeons' instruments being made in that town, whatever indications may be given to the contrary. Large quantities of the more common sorts of scissors are at present manufactured on the Continent, especially at Solingen in Prussia. The artists of this place strike upon their wares such English marks as may happen to be in repute, especially in the United States, whither there is a constant exportation of the Solingen scissors. It has been said that the extent of this export amounts to three fourths of the entire demand. The Sheffield scissor-makers have certainly been considerably reduced in number within the last ten years. Whether, however, this arises from foreign competition, or from other causes, is not so clear. The constantly recurring disputes between masters and workmen on the score of prices have been most injurious to the cutlery business both at home and abroad, less indeed from any consideration of the prices themselves, whether high or low, than in consequence of the uncertainty which such a state of things must needs introduce into the market. Manufactures of the description alluded to are mostly sold from patterns, stitched on cards, with current terms attached; and as the spirit of competition requires that these terms be adjusted very nicely to a scale of small profit on quick returns, it often happens that before a set of pattern cards with new prices can reach

America, or have begun to circulate there, some alteration takes place at the seat of manufacture, and other cards and corrections must be sent out, so that the suspicions, uncertainty, and annoyance of the foreign merchant, all act as a discount upon the integrity of the British manufacturer; the latter, meanwhile, often being nowise to blame for the fluctuations of which, in common with his customer, he is the victim.

Strong shears, having generally the shanks of a considerable length in proportion to the blades, are made for every class of artisans using sheet metal. Some of these instruments are of extraordinary size and power, and will, when one mandible is fastened to a block, and the arm of the other used as a lever, cut a plate of brass or copper a quarter of an inch in thickness. Others are smaller, and are used like a pair of scissors: this latter class is occasionally manufactured with crooked blades, for the purpose of cutting out pieces of metal in a circular form. The Society of Arts, in 1827, presented their silver Vulcan medal to Mr. Collett, for his communication of a pair of improved shears for cutting tags for laces. The metal used for these tags is very thin tin or tinned iron, and the usual method of giving the little bits of plate a channelled shape, fit for the reception of the lace, rendered it very liable to cut the fingers of the people employed in that manufacture. Mr. Collett's improvement consists of a pair of stout shears, *fig.* 14.; the upper part of the lower jaw *a* is a groove, the interior longitudinal side of which forms one of the cutting edges of the shears; the piece *b* is

Fig. 14.



screwed to the upper jaw *c*, and is formed at the bottom so as to fit the groove in the lower jaw. The piece *d* is screwed to the lower jaw; it is flat at the top, and extends parallel to the exterior side of the groove. The slip of tin plate to be cut into a tag enters between the jaws of the shears from the sides opposite to that shown in the figure, and is laid upon the piece *d*, projecting to the outer edge of the piece. The jaws are then closed, in consequence of which the tag is cut off by means of the sharp edge on each jaw; while at the same time the piece *c* entering the groove in the lower jaw, presses down the intervening piece of tin, and thus gives it the form of a hollow semi-cylinder, in which state it is ready to receive the end of the lace.

Wool-shears, or such as are used by shepherds in clipping the fleeces from the bodies of living sheep, belong to this branch of the cutlery trade. These instruments, which are of ancient use in this and other countries, instead of being composed of two separate blades working upon a pin like a pair of scissors, and thus having the force of a lever of the first kind *, consist, as is well known, of a strong spring forming the head or hand-hold, the blades extending therefrom in one piece. The instrument is kept to the cut by a peculiar management in the hand of the shearer, the blades having the power of two levers of the third kind, the common centre of motion being at the springing bow. Shears of this description are of course forged and ground in their straight or extended shape, and afterwards bent, so as to form the elastic bow, and bring the blades into the contact required for their special purpose. Two patents have been obtained for improvements in wool-shears, with reference to increasing the comfort and efficiency of their management: in both cases the innovations consist in the insertion of a secondary spring withinside the circular elastic hand-hold already mentioned. The contrivances are called V or W springs, as they are respectively, from being simple

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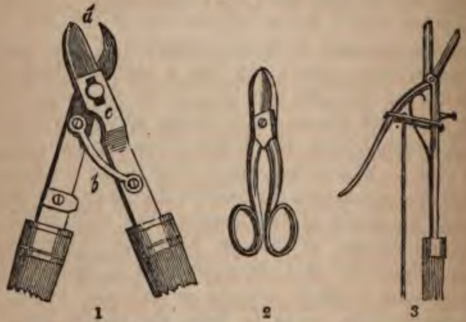
* See Mechanics, Cab. Cyc. p. 167.

Fig. 15.

or compound, supposed to resemble those letters. A pair of wool-shears, with the latter description of spring, is here represented.

Important improvements have of late years been made in the construction of garden shears, of which there are several varieties. The figures below represent, 1 the bough-lopping shears, of extraordinary power; 2, the pruning scissors, with circular edge; and 3, the grape and flower gatherer, four feet long. As these useful and ingeniously constructed instruments cannot be too well known, as well to amateurs as to professional gardeners, the following notice of them may be taken as the testimony of a very competent judge in such matters: — "We have seen (Gardener's Mag. June, 1830,) some very handsome pruning instruments of the sliding-shears description, manufactured by Steers and Wilkinson of Sheffield. The largest size, resembling common hedge-shears, cost about fifteen shillings a pair; and with them a man may cut through a branch as thick as his arm with ease. The smaller sizes, at from four shillings upwards, are particularly adapted for gar-

Fig. 16.



dening ladies; as, with them, the most delicate hand and arm may cut off branches from prickly or thorny plants, or from trees and shrubs, of any kind, half an inch in diameter. By using both hands, the most delicate person may cut through a branch of an inch in diameter. The great advantage of these instruments is, that they amputate by a draw-cut like a knife, instead of by a crushing cut like common scissors, or hedge-shears. This is effected by the spring lever, *b*, and the oblong opening, *c*, by which a compound motion is produced in the cutting blade, *d*. Neither these instruments, nor the very excellent grape and flower gatherer manufactured by the same party, are of recent invention; but they have been improved on by Messrs. Steers and Wilkinson in various ways, and are so admirably adapted for lady gardeners, that, considering the views we have as to the suitableness of certain parts of gardening for females, we cannot sufficiently recommend them."

In the Repertory of Arts for 1817, there are cuts of five or six varieties of garden-shears on the principle of Wilkinson's, comprising a groove in which the rivet works, or rather which allows one of the blades, by means of a lever attached to the opposite shank, to unite with the motion of the scissors or shears a drawing motion similar to that given to a pruning knife. These pruning instruments are ascribed to Mr. James Ogden, at T. D. Astley's, Esq., Duckenfield, Lancashire, who received for his improvement ten guineas from the Society for the Encouragement of Arts, &c.

Snuffers.

Constructed on a similar principle with scissors, though entirely distinct in their manufacture and use, may be here mentioned that well known domestic implement *the snuffers*, an article which our prevalent habit of lighting lamps or candles, to prolong as it were the day for the purposes of industry or pleasure, and the general cleanliness of all classes of society, has rendered universally necessary. The ordinary snuffers not being convenient for the removal of the obstructions generated on wicks when oil is burnt, Mr. Champion of Sheffield devised what he calls the "pelican lamp scissors," the blade of which is supposed to bear some resemblance to the bill of the bird above named, and which, being made thin and sharp, and working in a shallow box, appears much better adapted to snuff the wicks of argand burners than either the common snuffers or scissors, which are generally used as more manageable. The introduction of gas in most large towns, by having superseded, to a great extent, the consumption of oil as well as candles, has, at the same time, proportionately affected the demand for snuffers. The metallic-wick candles, requiring no snuffing, has also materially interfered with the manufacture of snuffers.

Snuffers, as already intimated, are in reality a kind of scissors, constructed not only to cut off the excrescence which accumulates on the wick during combustion, but at the same time to convey the snuff itself into a box or cavity. Very few ancient snuffers have come down to us: so far as can be judged from the appearance of such as have been casually preserved or represented, they must have performed the operation very indifferently, elegant and expensive as they may have been,—much worse, indeed, than it is now every night performed in the poorest cottages in the kingdom by instruments of the value of a few pence. Those who may be curious to see a representation of a pair of ancient snuffers, will find a cut of such in Hutchins's History of Dorsetshire. They were found in digging the foundation of a granary at the foot of a hill adjoining to Cotton mansion-house (formerly the seat of the respectable family of the Mohuns). They were of brass, and weighed six ounces. "The great difference," says Mr. Hutchins, "between these and modern utensils of the same name and use, is, that these are in shape like a heart, fluted, and, consequently, terminate in a point."

They consist of two equal lateral cavities, by the edges of which the snuff is cut off and received into the cavities, from which it is not got out without particular application and trouble. There are two circumstances attending this little utensil which seem to bespeak it of considerable age: the roughness of the workmanship, which is in all respects as rude and coarse as can be well imagined, and the peculiarity of the form." Hone, in his Every-day Book, gives a figure of an antique pair of snuffers, exactly agreeing with the foregoing description.

Snuffers for common purposes are, at present, made in very great quantities, not only of brass and of wrought iron, but, as mentioned in a former volume, thousands of grosses are cast immediately from pig-metal, and being subsequently annealed, they are filed, brushed with emery, or burnished, so as to look very well; and as the cutting edge does not soon wear away, they are not ill adapted for use. The best polished snuffers are made of cast steel, which has been decarbonated in order that it may work freely upon the anvil, and at the same time retain that peculiar compactness of grain which cast steel so beautifully exhibits. Articles of this description are finished to a certain point; that is, perfected as to form and fitting, and then case-hardened, after which they are susceptible of that fine black lustre or polish peculiar to cast steel. Trays of a similar material, and got up in the same style, are sometimes manufactured: these, when etched with landscapes and other subjects, have an exceedingly rich and elegant appearance.

To describe the great variety of snuffers which fashion and ingenuity have devised, would be tedious and difficult, even with the aid of numerous cuts. As an improvement upon the simple principle of cutting off the top of the wick, and conveying it into the receptacle, — out of which, however, the contents are constantly liable to fall, — sundry devices have been conceived and executed to close the box during the opening and the operation of the cutter. This desideratum is effected, in some sorts of snuffers, by means of one tube revolving inside another; and again, as in the case of Hobday's patent, by the rising and falling of a steel slide or cutter, which at once hides and retains the snuff in the box. This latter is an elegant and ingenious device; the only objection to snuffers on this construction being, that every operation is accompanied by a disagreeable snap of the machinery, somewhat like that occasioned by the closing of a common rattrap. Snuffers of all sorts have a coiled steel spring in a cell of the shanks, where the rivet is placed, in order to keep the box closed by the cutter when not actually in use.

CHAP. III.

INTERCHANGEABLE USE OF INSTRUMENTS OF AGRICULTURE AND WAR.—SCYTHES AND SICKLES.—FLEMISH REFUGEE WORKMEN.—SEATS OF MANUFACTURE. — COMMON METHOD OF MAKING SCYTHES.—PATENT, OR ROLLED, BLADES. — HAY AND STRAW KNIVES. — SICKLE-MAKING. — REAPING HOOKS. — HAINAULT SCYTHE.—REAPING AND OTHER MACHINES.

There can be no doubt that, in all places where the knowledge of metals and the art of working them existed, the fabrication of implements for the use of the cultivator of the soil would accompany the manufacture of arms, even if that might not anciently be common, which we have occasionally heard of in modern times,—the adoption of the scythe for the sword, or, *vice versâ*, according to the exigencies of the case. The Jews, in particular, appear not to have been unaccustomed to beat their swords into ploughshares and their spears into pruning-hooks; neither to the practice of restoring the material to its more pacific purposes when their wars were over. Hence the Scripture exhortation to that people,—"Beat your ploughshares into swords, and your pruning-hooks into spears."—Joel, iii. 10. And the prediction of the prophet, that "They shall beat their swords into ploughshares, and their spears into pruning-hooks," Isaiah, ii. 4.; reaping instruments are probably meant, rather than pruning knives merely. Virgil alludes to similar transformations of the implements of husbandry into weapons of warfare:—

"Et curvæ rigidum falces conflantur in ensem." *Georg.* i. 508.

Translated, by Dryden,—

"The crooked *scythes* are straighten'd into swords."

Or, according to Stawell,—

"And crooked *sickles*, now for battle made,
Assume the temper of the soldier's blade."

In ancient eastern agriculture, the scythe, as we understand the signification of the term, was little if at all known, grass being generally eaten off the ground, and reaping confined to the corn crops. Be this as it may, the two instruments appear, at an early period, in England sufficiently to have resembled each other, to render a supposition of their interchangeable use, at least, reasonable. Of so great antiquity is the scythe in this country, that the learned Verstegan endeavours to derive the appellative *Saxon*, the meaning of which has so much puzzled antiquaries, from an allusion to the broad crooked swords, resembling scythes, worn by the first Saxons,—ꝺaıꞅen being the word which, in their language, signifies a scythe: and "because," says he, "these swords were long and bending like a scythe, having the edge the contrary way."

It appears from drawings in the margins of ancient Saxon and Anglo-Norman manuscripts, engraved by Strutt, in his "Manners and Customs of the People of England," and, certainly, the oldest illustrations extant of the dresses, avocations, and implements of our ancestors, that the scythes and the sickles of the present day differ hardly at all from those in use nearly a thousand years ago. The sickles appear to be exactly similar; and, with regard to the scythes, almost the only discernible difference is, that those in the pictures have a long straight shaft, instead of the curved snaith to which the blade is at present affixed: they had, likewise, in the earliest state, apparently but one handle affixed to the shaft instead of two, as is now commonly seen. In Wales, however, according to Giraldus Cambrensis, the reapers did not use the sickle in common with their northern neighbours, but an instrument like the blade of a knife, with a wooden handle at each end. It is by no means easy to perceive what can have been the advantages of such an instrument.

Among the instruments, supposed to have belonged to husbandry, which have been discovered among the ruins of Pompeii, may be mentioned the sickle, very nearly resembling that commonly in use at this day in England.

Scythes and sickles, especially the former, are at present manufactured in various parts of the country By far the greater proportion, however, of both of these descriptions of reaping instruments are made by workmen scattered over a district extending about six miles south of Sheffield, and which district has been the seat of this staple for at least three hundred years. The sanguinary persecution of the duke of Alva in the Netherlands, which compelled so many protestant families to seek as refugees in this country the exercise of that liberty of conscience which, as citizens, they were denied in their own, was, as is well known, the means of bringing into England many of those useful arts which have ever since flourished. Amongst these fugitives came over a party of Flemings, whose occupation had been the manufacture of the class of instruments now under consideration. These artists were invited or encouraged by the then earl of Shrewsbury, to fix their residence in the neighbourhood of the town, in the rising celebrity of which he felt so much interest. The patronage of a protestant nobleman, whose influence was so considerable, and the proximity of a town where the manufacture of edge tools was so largely carried on, were favouring circumstances; the foreigners accordingly settled themselves, the scythe-makers in the parish of Norton, and the sickle-makers in the parish of Eckington, parochial adjacencies forming together the northern extremity of the county of Derby.

In all probability, the first settlers divided their industry between manufactures and agriculture, an arrangement by no means obliterated among their descendants and successors at this day. The nearness of these artificers to the town of Sheffield enables them to take every advantage resulting from the cheapness or the qualities of iron and steel suitable for their purposes. On this account, and the goodness of the workmanship, the scythes and sickles of this neighbourhood are extensively known and in high reputation both at home and abroad, especially the sickles — the greater part even of those vended in the name of celebrated dealers in other districts of the country being, in fact, furnished to such dealers either in a finished, or more generally in a rough state, by the sicklesmiths of Ridgway, Troway, or Mosbrough. Sickles, like most other edge tools, are usually marked with some distinguishing corporation or other monogram, which gives confidence to the purchaser, and, consequently, a value to the article in the market.

Scythes are composed of iron and steel; the former forming the back and thicker portion of the blade, and the latter constituting the edge. Good shear steel ought to be used, the process of shearing having freed it from flaws by the welding of all loose parts; but bar steel in the blister state, or as it comes from the converting furnace, is not unfrequently worked up for this purpose, as being much cheaper than the other sort. The two metals, which have been manufactured of a sufficient substance to form their respective portions of the blade, are cut into proper measures, and then welded together throughout their length; the iron rod being left so as to extend several inches beyond the steel, for the purpose of forming the tang of the scythe. The blade is then drawn out, by means of hammering on the anvil, to its proper size and shape by the maker and striker; the back being at the same time left of a considerable strength. This thick back is in the next place knocked up, or partially overlapped, so as to form a strong band or swell of iron along the outer margin, for the purpose of stiffening the blade. This operation is readily performed by the hammer-man, who, placing the red hot blade inclining a little with the edge upward, and the thick part upon the anvil, strikes it with the peal or sharper end of his hammer, the other workman, meanwhile, propping it on the opposite side with an iron tool, to prevent it from sliding along upon the anvil with every stroke. This bending or turning up of the back is still further perfected upon a shape-iron, and by finally squaring and making fine the work upon the acute edge of the anvil which is adapted for this purpose. The blade is then smithed, *i. e.* cool-hammered, set and hardened in the usual manner, and afterwards tempered, by drawing it carefully over the hearth fire: after being again examined it is carried to the grinding wheel.

The stones used for the grinding of scythes are of the largest size, being from six to eight feet in diameter, and ten or twelve inches in thickness. The neighbourhood of Newcastle-upon-Tyne is celebrated for excellent grindstones, including some of a peculiar grit used by the scythe makers. The face, instead of being quite flat is convex; or a segment of a circle nearly agreeing with the concave line of the edge of the blade, which is shaped by an application to the stone. The stone runs in a trough of water; and in a direction contrary to that of grindstones in general; namely, *towards* instead of *from* the workman, who, consequently sits *before* rather than *behind* the stone. His position, however, can hardly, with propriety, be called sitting; for, although he has a sort of seat or saddle firmly chained to the timbers, like a knife-grinder's horsing, he, at the same time, rests upon his feet, his body hanging in such a position over the stone that he is enabled to throw his whole weight upon the work. The blade, during this operation, is held with the back from the grinder, under a strip of wood extending nearly over its entire length. After having been passed over a glazier of emery, and set, by striking it with a hammer on an anvil, or a block of wood, somewhat after the manner of setting a saw, the blade is varnished on the black, and oiled on the bright parts, after which it is ready for packing. Scythes, when made up for the market, are tied in bundles of a dozen together, and closely wrapped over with a straw band from the heels to the points, the maker's name being struck upon that part which is exposed. Fussel, of Bristol, a celebrated maker of these and similar articles, is, perhaps, the best known in London; Griffin, of Dudley, has likewise considerable celebrity; the scythes from his establishment are all sealed by the maker, by way of warranting the genuineness and quality of the article. The name of Biggin, of Little Norton, is widely known and accredited as an excellent mark of long standing.

Besides the common descriptions of scythes manufactured upon the anvil in the manner above described, there have long been in demand a variety depending for their excellence upon the economical application of a much more valuable material, and denominated patent scythes. The instrument, when of this description, is composed of a web of cast steel, cut from the sheet with shears, to the proper shape, and then riveted to an iron rib or back. This web is carefully hardened, tempered, and ground before it is attached to the back; and, being made of the best material and very thin, it not only cuts, in most cases, with great sweetness, but can never, by wearing and whetting, acquire that stumpy edge which characterises the nearly worn out scythe of the old description. On the other hand, it is alleged, not only to be liable to break if the material or the tempering should be defective, but to want those advantages resulting from weight of metal combined with regular stiffness of form, so essential to usefulness, where the mower has to encounter coarse, strong crops, or to work over ground scattered with stumps or stones, as often happens in new situations. Ibbotson Brothers, of the Globe Works, Sheffield, who are large exporters to America, profess to warrant every scythe made by them of this description, to be capable of an edge by the most simple mode of whetting, *equal to the best made razor* from the most approved and eminent manufacturer; they likewise engage for the article to stand every kind of usage which can reasonably be required of a scythe. These scythes are warranted so hard as to cut the iron part of *an anvil*, properly directed, with little injury to the edge; yet of such elasticity that, when separated from the back, they may be rolled up a hundred times, and put into a man's hat, and still return to their original shape.

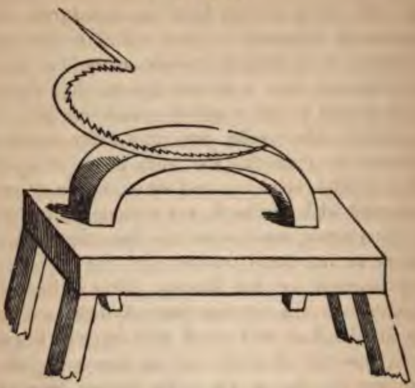
Hay and straw knives are manufactured by the scythe-makers generally. Mr. Griffin, of the Whitty Moor Works, near Dudley, whose name has been already mentioned, has a patent for manufacturing, by means of rollers properly grooved and indented, scythe backs, chaff-knife backs, and hay-knife backs, with raised studs or pegs for the purpose of riveting the cast steel blades thereto; and which studs or pegs, as they are solid with the back, are considered to leave the articles thus made much stronger than those which are perforated in the usual manner for the pins that are used for riveting on the blades. This is certainly an improvement in the construction of these articles, especially of the hay and chaff knives, which are frequently subjected to more severe stress in use than scythes; for the latter are rarely known to give way, even when the backs have been bored; notwithstanding, as Mr. Griffin observes, such backs must be "considerably weakened, as, in each place where a hole is formed, there is nearly a third of the width of the metal removed."

Sickles, as well as scythes, are formed, by welding to a piece of iron, of the proper length and thickness, a shred of shear steel, both substances being then drawn out together by the maker and striker, upon the anvil to the size intended. The back of the sickle being so much thicker than the edge, and the blade narrow, the form is perfected by hammering in a grooved steel boss. The sickle is then heated again, and bent into the desired shape over the anvil, the maker having before him a pattern article; it is then carefully smithed, the shape corrected, and afterwards taken to be rough ground.

The next operation is cutting or toothing, or *tedding* as it is technically called. To perform this process the workman sits astride upon one end of a stout bench.

toward the middle of which is inserted a strong bent piece of iron called, from its shape, the *brig* (bridge); behind this, and upon the other end of the bench, so as to be opposite the workman, sits a boy, who, holding the sickle by each end, in the position represented in the cut, keeps it flat and steady upon the brig during the operation of cutting, and moves it gradually onward from heel to point as the work proceeds. The toothing is effected by a small well tempered chisel and a hammer, much in the same manner as in the cutting of files. There is, however, a peculiarity in the handling of his hammer and chisel by a sickle tedder, which it requires considerable practice to attain, and which differs so much from the manipulation of similar tools by the file-cutter, that the latter, however dexterous a workman, can hardly ever succeed in the performance of an operation apparently so much resembling his own.

Fig. 17.



The sickle, after being in the next place hardened and tempered in the usual manner, is again ground; by which operation not only is the surface rendered bright, but by the removal of a burr produced on the under side by cutting, the teeth of the instrument are perfected as to keenness as well as figure; the surface is then glazed with emery, and the sickle is ready for hafting. To perform the latter operation, the tang of the instrument is heated to a low red, and then held in a vice, while the handle is driven on with a hammer, the hafter at the same time taking care that the sickle be set neatly and in the position proper for use. The handles, which rarely split during the foregoing operation, are made of any kind of soft, light, cheap wood, generally birch, owler, or sallow; they are expeditiously turned at a lathe, two together, and while revolving are ringed, by way of ornamenting them, with turmeric or some other dye.

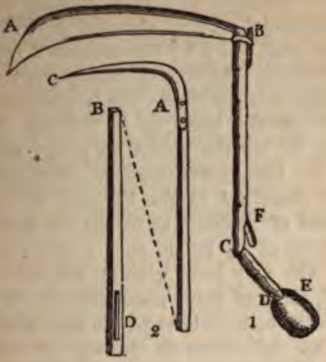
Always carried on with the foregoing articles is the manufacture of what by the trade are termed *hooks:* these are instruments of the size and shape of the sickle, though in their fabrication and cutting principle they rather resemble the scythe. Instead of having the blade narrow, and with a thick back like the sickle, they are at least an inch broad in the web; instead of being serrated on the edge, they are ground there like the scythe, so that they may be whetted and kept in order with the strickle, an advantage which does not attend the use of the sickle. These articles are chiefly preferred by the Irish and Scotch reapers; they are likewise in considerable demand for the foreign markets, large quantities being annually shipped for Holland, Poland, Russia, America, &c.

It has been objected against the use of reaping-hooks that, being ground smooth and sharp on the edge, they often cut the straws while entering, and before the reaper has gathered them into his hand, so that such loose straws fall upon the ground. To obviate this objection Mr. Hutton, of Ridgeway, made, in 1807, a reaping-hook, for which he was rewarded with a medal from the Society of Arts: his hooks are hacked through almost half their length like a sickle, and the remainder was ground sharp. A considerable number of this description of instrument were soon after sold.

Sickles, as well as hooks, are made of various sizes, generally from thirteen to thirty-two inches in length, and sometimes, in sickles, reaching to thirty-six inches: these uncommonly long instruments are, however, confined in their use to England; the Dutch, as well as the Poles, rarely liking sickles or hooks more than from thirteen to sixteen inches in length. Sickles are sold by the ironmongers throughout the country: as dealers, Powell, of Northampton, and Tomline, of Kettering, are celebrated; and still more so, several individuals where the chief manufacture is seated, in the neighbourhood of Sheffield, at the hamlets named at the beginning of this article.

Attempts have at different times been made in England and Scotland, and also in Wales, to introduce to the approbation of the peasantry the implement generally known as the Hainault scythe, and brought hither from French Flanders, where it is called *piquet* or *petite faulx* (little scythe). The material of the Flemish scythe is very different from that of our own: in Hainault, the steel is so soft, that when it becomes blunt it is merely whetted on the staff of the crook, which there is of oak; but when the edge is materially injured, it is beaten till again sharp and smooth with a hammer on a small anvil, both of which the mower carries to the field. This scythe consists of two parts, the *piquet* and the *crotchet*. The piquet blade, A, is twenty-one inches long, and $2\frac{1}{8}$ inches broad; it is fixed into the handle by two wedges at B. The handle from B to C is seventeen inches long, and from C to D five inches and a half. E is a wooden knob about four inches long, which serves as a balance, and to help the workman. F is a small leather strap, in which the mower inserts his fore-finger. 2. is the *crotchet* or hook; the workman uses it with the left hand to gather the quantity of corn he intends to cut, to support it when he is cutting, and to lay it afterwards behind him. This hook has a handle A B of the length of three feet five inches; its shape is square; and the iron part is in length from A to C about ten inches and a half. D is an opening for the purpose of inserting the blade, so as to prevent the workman from being hurt when carrying the implement. Although stated to be well adapted for cutting strong corn, this Flemish scythe does not seem to be adapted to the taste of British reapers in any part of the kingdom.

Fig. 18.



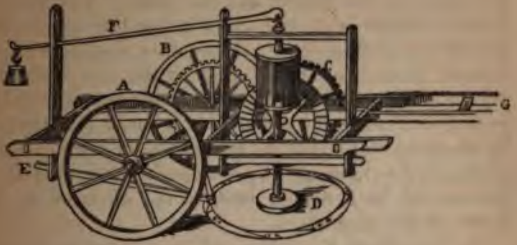
It is not surprising that an age of ingenuity like that in which we live, and which has witnessed such and so many signal triumphs of machinery, should have suggested the possibility of superseding the ordinary operations of the scythe and the sickle, by some contrivance calculated more expeditiously and economically to reap the produce of the field. Accordingly, for several years in succession, but without success, the Society for the Encouragement of the Arts and of Agriculture announced for public competition their large gold medal to be awarded to any person who should fulfil certain conditions by the invention of a reaping machine.

Within the last twenty years, however, various attempts have been made by ingenious individuals to construct machines, by means of which horse labour should be substituted for human strength. These have generally been on the principle of giving rotatory motion to a circular horizontal cutter, elevated a little from the ground, and kept sharp by the continued application of a fixed whetstone. In most of these plans for superseding the scythe and the sickle, the implement, instead of being drawn by the horse as in the case of a cart, is forced along before the animal as a man wheels a barrow. In Mr. Plunknett's machine, however, which is figured and described in the Farmer's Dictionary, the horse, instead of pushing, as in the old method, tracks from the front of it, but in such a manner as to clear the crop. On very level ground, and when the corn stands well, some of these machines may be used with comparative success, at least in the way of experiment; but there are difficulties in the way of regulating the application of the cutter, or cutters, maintaining a keen edge, and especially in so laying down the straw, in order to its being bound up in sheaves, that it may be conveniently collected, that, practically speaking, a reaping machine remains as much a desideratum as ever.

To convey a more distinct idea of the difficulties to be overcome in a project of this kind, by showing what has been done in a single instance, it may be mentioned, that a machine for mowing grass, or what may be denominated a revolving scythe, was constructed, several years ago, by an individual of the name of Bailey, of Chester county, in the United States, and for which he obtained a patent. According to accounts from America, this machine was used with considerable success in the neighbourhood of the patentee's residence, in the summer of 1822, when twenty acres of grass per day were cut down by it. This machine is represented in the annexed engraving, *fig.* 19.

A B are two wheels of equal sizes, which support the machine: the former revolves on its axle, in the usual manner of a coach-wheel; the latter, which is advanced about a foot, is attached to its axle, so that they revolve together. This wheel, which works within the frame, has a circle of cogs screwed upon the outside of the felloes, but a little within the circumference, that they may not touch the ground: these cogs work into those of the wheel C, which is placed upon an axle, which carries likewise another with face-cogs, so as to give motion by means of a trundle-head to a vertical shaft of iron. To the bottom of this shaft, which reaches towards the ground, is fixed a circular horizontal table D, which is about four feet in diameter, and on the circumference of which six scythes are fastened in a horizontal position, and so as to compose a complete circular edge. To keep the scythes at a proper distance from the ground, the bottom of the shaft is supported on the end of the piece E, in which it works and is retained; so that, according to the inequalities of the ground, the scythe-frame, shaft, and the trundle-head rise and fall together.

Fig. 19.



To keep the scythe sufficiently sharp, its edge is made to pass, during its revolution, under a circular whetstone, that likewise revolves with the scythe. This stone is fixed to a sliding rod, by means of which it rises or falls with the scythe. To regulate the pressure of the trundle-shaft and scythe-frames on the ground, the lever F is fixed to the top of the machine, and the weight removed backwards or forwards, according to the nature of the ground and the grass. The horse is yoked in shafts at G, and walks in front of the farther side of the machine, and, consequently, is always on the mowed ground after the first swath has been cut. By the increase of velocity, the scythe revolves with the greater swiftness: the grass, as it is cut, is first thrown, by the progressive motion, against the rise in the centre of the scythe-frame, and, by the same motion, afterwards thrown off, in a regular row, in the direction of the centre of the machine.

At the Great Exhibition of 1851 considerable attention was directed to the Reaping Machines exhibited in the American department, and to the corn and grass cutting machines which were shown in the English agricultural section.

A full account of these machines will be found in "Hunt's Hand-Book to the Great Exhibition:" but the following more condensed description is derived mainly from the lecture delivered at the Society of Arts, on the "Agricultural Products and Implements," by John Wilson, Esq.

I feel bound to record amongst the many claims which Roman Agriculture has upon our memory that of having possessed a reaping machine, which was commonly and advantageously used in certain districts where the fields were large, and the land level. This machine is described at some length by Palladius, and is also mentioned by Pliny, as being in use at the time he wrote.

At the commencement of the present century we find a machine was introduced by Mr. Boyce, in which short scythe-like knives, attached to a revolving cylinder was the method by which the cutting process was carried out. In Plucknett's machine already mentioned, a sickle edge was substituted for the scythes of Boyce. In 1806, Gladstone, a Kirkcudbright mechanic, carried the improvement still farther, as his machine (revolving cut) possessed an arrangement for gathering the cut corn and delivering it in small bundles or sheaves. In this the power was applied at the side; in the former ones it was applied at the back; in the one *drawing*, in the others *pushing*, the machine. The next attempt was by Salmon of Woburn. Instead of the circular cut of those which preceded it, he made use of a cutter with long blades, working in a straight line by a reciprocating movement: to which was also combined an arrangement for gathering the corn and laying down its swathes. James Smyth, of Deanston, and several others, devised various forms of reaping machines, all of which were more or less successful, but none of them perfectly so, under all the required conditions. Ogle's machine, described in the Mechanics' Magazine for 1825, has been reproduced in the machine which was so prominently brought forward under the name of M'Cormack's. The framework was made like the skeleton of the body of a cart, to which were attached wheels and shafts; the horses were yoked in the usual manner, and walked by the side of the standing corn. To the right of this carriage was projected the cutting apparatus; a light frame, whose front bar was of iron, and armed with a row of teeth three inches long, projecting forwards. Immediately upon these teeth lay the cutter, a straightened steel knife, a little longer than the breadth of the corn to be cut at one passage. Bell's machine, invented in 1826, has been in constant use in the Carse of Gowrie for fourteen years; it is reported to have cut down beans, wheat and oats, at the rate of one acre an hour, in first-rate style. M'Cormack's second patent, in 1845, introduced several improvements into the machine; the angle of the sickle teeth were reversed alternately; the form of the fingers to hold up the corn was improved; an iron case introduced to preserve the knife from clogging; and the mode of separating the standing corn to be cut was greatly improved upon.

In the "History of Metal Manufacture," it would be improper to omit some notice of the various machines which have been constructed for agricultural purposes. Amongst others, we have steam engines, thrashing machines, winnowing and shaking machines, cutting and crushing machines, and tile and brick making machines. The number of implements for operating on the surface, and for moving the superficial earth, are very great. Harrows have been manufactured of almost every variety of form. Horse rakes and hoes are very numerous, and many of them most ingenious. One of the most valuable and effective instruments recently brought forward is Garrett & Son's drill, for seeding and manuring land. It consists of a pair of wheels and an axle, from which are suspended a set of levers, having hoes of different shapes, as many as may be required, attached, working independently of each other, and capable of being set at any desired depth, by means of regulating keys; so that however uneven the surface of the ground may be, all the weeds growing on it was sure to be cut up. A swing steerage, acting upon all the levers, gives perfect command over the line of the hoes; thus any irregularity in the drills may readily be followed without any chance of injuring the plant. The hoes may be varied in distances so as to suit the different widths of the drills, and a simple arrangement exists for raising the whole of the levers at once, when required for clearing the hose, or in turning. On the fore part of the carriage is fixed a box similar to the broad cast barrow, for sowing small seeds, the spindle being worked by a pulley and strap from the large wheels. The spouts are brought down to the ground, and have large flat mouths, so that the seed may be well scattered between the drills, the hoes then follow, and by paring the surface, prepare a sufficient seed bed for them.

The *Iron Cultivators* are powerful implements, usually in the form of an irregular pentagon, and carried on two large travelling wheels. Iron clod-rollers are again an important introduction of the metal manufacture to the agriculturist. For full descriptions of these the reader is referred to the Jurors' Reports, and to the Illustrated Catalogue of the Great Exhibition.

CHAP. IV.

MILITARY WEAPONS.

SPEARS AND AXES OF EARLY FORMATION. — SAXON AND NORMAN WEAPONS. — SWORDS OF WOOD, COPPER, AND OTHER SUBSTANCES. — MANUFACTURE OF SWORDS BY THE TURCOMANS. NORIC AND SPANISH SWORDS. — MILAN BLADES. — DAMASCUS SABRES. — SWORDS NAMED, AND USED AS CROSSES. — BRITISH SWORD CUTLERY. — ANTIQUE SWORDS.—AUSTRIAN SWORD. — SWORD TRADE IN ENGLAND. — PROCESS OF MANUFACTURE AT BIRMINGHAM. — BAYONETS.

UNDER the foregoing designation may be comprehended most of the instruments, exclusive of fire-arms, which have been used in warfare, ancient or modern, savage or civilised, for the destruction of mankind. These instruments may be divided generally into three classes, which, according to the most probable order of their invention and their comparative efficiency, may be enumerated as follows:—1. arrows and spears; 2. axes; and 3. swords.

In the flint-headed arrows, the bone-headed javelin, and the stone-edged battle-axe of the most savage nations, we recognise the originals of the first and second classes. The former of these, indeed, are abundantly diversified, as well in regard to their use as their elegance, even among barbarians, from the clumsy pike of the Hottentot to the delicate arrow of the South-sea islander. In the infancy of knowledge, even in countries where the smelting of metals might not be unknown, the spear, whether regarded as a missile, or as an instrument for close fighting, must obviously have been, on account of its simplicity of construction and adaptation for use, the earliest form in which an offensive weapon would suggest itself to mankind. And this supposition perfectly accords with facts recorded by various authors, and which, from their number and familiarity, must instantly present themselves to the recollection of almost every reader. To the spear, as a light weapon for throwing to a distance at an enemy, or for fighting on the nearer approach of the combatants, would naturally succeed the heavier axe to be used in close engagement: and although, in the first instance, it might be made rather ponderous, with the design of giving a heavy stroke, than sharp, for the purpose of cutting, such a weapon would always be wielded with dreadful effect by men bent on carnage, and actuated by no milder principle than unmitigated revenge.

Although, among modern civilised nations, the military axe has long been unknown, and even the spear is retained at present more as a formal than a fighting instrument, nevertheless, with the ancient Greeks and Romans, and the warriors with whom they contended, these weapons were in universal use. It would be an endless, as well as an uninteresting, task to give even a catalogue of the different terms by which the ancients distinguished all the weapons of the above-named classes, or to cite the various passages in which they are referred to by classical or other authors. To the Romans, as the conquerors of this island, as well as to invaders from the north, our ancestors were doubtless indebted for many of their military weapons, especially of the sorts above mentioned. Of these arms, to which (at least to the men by whose prowess they were wielded) this country may be considered to be even at this moment indebted, the following figures and descriptions, copied from Strutt, who himself derived them from old manuscripts in our public and other depositories, cannot be considered uninteresting or out of place.

Fig. 20. *a*, The gaveloc, or javelin, used by the footmen. *b*, The gisarma, called by Chaucer a *brown bill*. *c*, A tilting spear. *d*, A spear used for galling the horsemen. *e*, A battle-axe. *f*, The bipennis, or double-edged axe. *g*, A glaive. *h*, The pole-axe, or bill. *i*, A Norman bill. *k*, Another bipennis. *l*, A war axe used on board ship. Besides this diversity of weapons, many others, of which the names, if not the

Fig. 20.

figures, might easily be added, our ancestors occasionally resorted to a description of "small arms," of a class which would not be deemed very legitimate, nor indeed very serviceable auxiliaries in modern combat. The duke of Orleans, in his challenge to our Henry IV., requires that no incantations be employed; that they should use lance, battle-axe, sword, and dagger, as they should think fit; but not aid themselves "by any bodkins, hooks, bearded darts, poisoned needles or razors, as may be done, unless ordered to the contrary."

The most common and effective military instrument in use among ancient or modern warriors, when fighting hand to hand, was the sword, under the diversified shapes and names by which that formidable weapon has been known. Swords made of bronze, of copper, and even of wood, have been common, in times and countries remote from our own: and so skilfully have the American Indians fabricated them of the latter material, that swords formed out of a peculiarly hard wood have, it is gravely asserted, been met with of a character so formidable, as to be considered hardly, if at all, inferior to those of metal. An assertion like this, however exaggerated it appears at first sight, becomes less questionable, when we consider that, for the purpose of stabbing at least, a stout well-formed instrument of extremely hard wood, could hardly fail to be a more trust-worthy weapon than a sword, the blade of which was of copper, or so soft a material, that the user is represented by historians as repeatedly placing it under his foot to straighten it, after becoming bent in his hand. And whoever may have seen the swords of these savages edged with sharks'-teeth, must instantly have perceived how well they were calculated to do horrible execution in hands accustomed to wield them. The aborigines of South America, dwelling in the regions of volcanic eruptions, made their keen-edged weapons of obsidian, a species of hard vitreous lava, not unfrequently found in the form of wedges. Humboldt says, the Mexicans dug obsidian in mines, which took up a vast extent of ground; and that of it they made knives, sword-blades, and razors.

According to Gibbon, it was during the inroads of the Sclavonians and Bulgarians on the western empire that the name of the Turks, afterwards the masters of Constantinople, was first revealed to the world. "At the equal distance of 2000 miles from the Caspian, the Icy, the Chinese, and the Bengal seas," says the erudite historian, "a ridge of mountains is conspicuous, the centre, and perhaps the summit of Asia, which, in the language of different nations, has been styled Imans, and Caf, and Altai, the Golden Mountains and the Girdle of the earth. The sides of the hills were productive of minerals; and the iron forges, for the purposes of war, were exercised by the Turks, the most despised portion of the slaves of the great khan of the Geougen. But their servitude could only last till a leader bold and eloquent should arise, to persuade his countrymen that the same arms which they forged for their masters might become, in their own hands, the instruments of freedom and victory. They sallied from the mountain (of Irgana-kon);

a sceptre was the reward of this advice; and the annual ceremony, in which a piece of iron was heated in the fire, and a smith's hammer was successively handled by the prince and his nobles, recorded for ages the humble profession and rational pride of the Turkish nation." It seems to have been owing to a singular fatuity, that the mistress of the world failed to become possessed of those resources of that most valuable of all materials for the sword, to which Europe has since been, to which Great Britain is, at this moment, so eminently indebted. The Turks, acquainted with the Northern mines, actually offered iron for sale; yet the Roman ambassadors, with strange obstinacy, persisted in believing that it was all a trick to lead to the belief that they possessed the material of warlike implements, and that their country produced none of it.

The Roman generals, and others in the army, who prided themselves as warriors upon the temper of their swords, frequently obtained their weapons at a great price from cutlers, who used a description of iron smelted in the district of Illiria, formerly called the Noric Alps: hence *Noricus ensis*, in the Augustan age, was synonymous with a good blade, as an Andrea Ferrara was in after times.

Spain, which, during the middle ages, was celebrated for the manufacture of swords of superior temper, still retains much of its ancient fame in the estimation of military men, few of whom visit that country without seeing at work the successors of those sword-smiths who furnished such admirable instruments during the Moorish wars. Within a couple of miles of the celebrated vega of Toledo, on the right bank of the Tagus, is seated the royal manufactory of arms, which was re-established by Charles III. at the close of the last century. "Here," says the author of a "Year in Spain," "are made all the swords, halberds, and lances, required for the royal armies. The establishment is on an admirable footing, and the weapons now made in it are said to be nowise inferior to those famous *Toledanos*, which, in more chivalrous times, were the indispensable weapons of every well appointed cavalier. Toledo was not only celebrated in the time of the Moors, but even under the Romans, for the admirable temper of its swords, which is chiefly attributed to some favourable quality in the water of the Tagus, used in tempering the steel. As a proof that this is the case, one of the workmen told me, that in the early period of the French invasion, the manufactory was removed to Seville, where the national junta then was; but the swords manufactured on the banks of the Guadalquiver, were found to be very inferior to those which the workmen had made in Toledo."

With the last-named place Bilboa might anciently have disputed the honour of being considered as the Birmingham of Spain: from this place was formerly exported hardware to a large amount, and more especially iron and steel in bars, of which prodigious quantities were about a century ago exported to England as well as France.

The crusaders, and contemporary warriors, not only derived their swords from Spain, but to a vast amount from Italy. Milan having been, during the twelfth and the following centuries, one of the most celebrated European marts for the sale of arms, furnished, says a writer in the Edinburgh Review, 1818, "all the arms used by the crusaders, and the princes of Europe. This city, at that period of her liberty, had a population triple what it is at the present day. It was said the country was depopulated to supply the manufactures of the towns."

In Ben Jonson's comedy of the "New Inn," acted in the year 1631, are the following lines descriptive of a finished beau of that age. He says,—

"I would put on
The Savoy chain,—about my neck the ruff,
The cuffs of Flanders: then the Naples hat,
With the Rome hat-band, and the Florentine agate,
The *Milan sword*, the cloak of Genoa, set
With Brabant buttons, all my given pieces;
My gloves the natives of Madrid."

The most famous sabres in the world were those manufactured in the east, many of which have come down to our times, and are highly prized, and sold for immense sums, whether regarded as curiosities merely, or as instruments for fighting vastly superior to the swords of modern European manufacture. These oriental sabres, which are invariably regarded by their possessors as being of great antiquity, are presumed to have been made at Damascus in Syria, Ispahan in Persia, or Cairo in Egypt; at none of which places, if we may credit recent visitors, is the manufacture of steel articles carried on at present. Some writers, on the other hand, assert that the Damascenes are still engaged in making swords. Of all the sabres, however, the fame of which has reached this country, those of Damascus are by far the most noted, most persons having heard of them, though very few individuals, indeed, have seen them, and fewer still have been the instances in which the blades themselves have confirmed those strange stories about their temper, which are so generally circulated, and received among persons who know but little of the nature of steel. The characteristics ascribed to the real Damascus blades are, extraordinary keenness of edge, great flexibility of substance, a singular grain of fleckiness always observable on the surface, and a peculiar musky odour given out by any friction of the blade, either by bending or otherwise. That their quality, undoubtedly excellent as it must be, has been greatly exaggerated there can be no doubt,—the extraordinary power of execution so generally accorded to the weapon having in most instances depended rather upon the strength and dexterity of the user. A gentleman, who purchased one of these sabres in the East Indies for a thousand piastres, remarked to the writer of this volume, that although the instrument was very flexible, and bore a very fine keen edge, it could not, with safety, be bent to more than 45° from the straight shape, and it was not nearly so sharp as a razor, yet, wielded by a skilful hand, it would cut through a thick roll of sail-cloth without apparent difficulty; a feat which could not be performed with an ordinary sword, nor, it should be observed, by the sabre itself, in an ordinary hand, though the swordsman who tried could, it appears, do nearly the same thing with a good European blade. That peculiarity, however, which, more than even the excellence of the blades, has excited the admiration and curiosity of Europeans, is the freckled or wavy appearance of the surface of the oriental sabres; and it may be regarded as a singular fact, that, notwithstanding our long connection with the East, the question appears to be yet unsettled, as to whether that appearance is produced by welding iron and steel together in a peculiar way, by the admixture of some foreign ingredient, or whether, in short, it ought not to be regarded as the natural grain of the indigenous material in its malleable state? The last mentioned of these theories appears to be the least probable, especially as the two former have been found, in practice, to produce at least analogous effects, as we have already mentioned in treating of steel, and as will be further instanced in the article on fire-arms. As to the odour alluded to as one of the tests of the real Eastern sabre, its presence does not appear to be universal, much less need we suppose that it is in any instance incorporated with the metal itself while in a state of fluidity. It is perfectly easy to conceive, that in countries where perfumes are so general, that what is applied to every thing else would be likewise applied to the sword; for a Mahomedan does not prize his beard more than he appears to value the instruments which are at once the pride of his equipment, the safeguard of his person, and the arguments of his faith. Emerson, in his letters from the Ægean says, "I have seen some blades (scymetar) which were valued at 200 or 300 dollars; many are said to be worth triple that sum, and all retain the name of *Damascus*, though it is by no means likely that they have been manufactured there. The twisting and intertwisting of the fibres of the metal are considered as the tests of excellence; but I have never seen any possessed of the perfume said to be incorporated with the steel in the real Damascus blades."

This celebrated oriental city, although no longer the seat of those manufactures which have made it famous throughout the civilised world, is nevertheless at this day no inconsiderable emporium for iron and steel wares of a similar class. Mr. Buckingham, the traveller, says, "Among the manufactures to be found in the bazaars of Damascus are very superb caparisons for horses, of which the Turks, and indeed all the eastern nations, are extremely fond. The best of these are considered to be made in Romelia, by which the people have generally understood European Turkey; a number of fine bridles, martingales, and silver and embossed pieces come also from Persia. The fire-arms are chiefly of French and German manufacture, but got up in a more highly ornamental style than would be pleasing to European taste, being expressly prepared for this market. Those who are the most choice, however, in the selection of their arms, prefer to have the barrels of their muskets made of the old wavy iron found in the ancient sword blades of the country, with French or German ornaments, but with English locks. The sabre blades are almost all of the old Persian or Damascus manufacture, the art of making them being no longer known or practised, so that they continue to increase in price as they grow older and scarcer; for there are no modern swords that can compare with them in quality. They are mounted in various ways, according to the taste of the wearer, but generally in what is called the Mamlouk style; and this is done at Damascus in a better manner than even at Cairo, where they pride themselves in this kind of workmanship."

During the early ages, European warriors frequently gave names to their favourite weapons; many of these are preserved by authors who have described military exploits. The sword of Magnus, an old king of Norway, was called by him *leg biter*. Every one has heard of *caliburn*, the celebrated sword of king Arthur, which our Richard I. sent to Tancred, and the value of which may be estimated from the fact that the heroic crusader gave to the English monarch in return "four great ships and fifteen galleys." An Andalusian, who always carries his sabre about with him, calls it his Santa Theresa, and says, that, when he draws it, "Trembla la tierra," the earth trembles. Camden mentions that the sword of the renowned Talbot, earl of Shrewsbury was found in the river Dordon, near Bourdeaux, many years after the death of him who wielded it, bearing this barbarous inscription,

Sum Talboti M IIII. c. XLIII.
Pro vincere inimico meo.

At a period when the zeal of the crusaders laboured to give the form of the cross to almost every object capable of being moulded by their pious ingenuity, the straight sword of a holy warrior, with a plain transverse guard, was without violence considered to represent the emblem of his Saviour's passion. It was, therefore, not uncommon for the expiring knight to fix his eyes upon his sword hilt as a lively symbol of his faith. The celebrated chevalier Bayard, "the knight without fear or reproach," when mortally wounded at the battle of Rebec, breathed his last words while kneeling before his sword as a representation of the cross. In the museum of armour at Madrid may still be seen several swords of the foregoing description, including those of the Cid, of Guzman, Gonsalo, and Cortez. "They are all," says a recent traveller, "straight, long, and two-edged, with plain scabbards of old velvet, and hilts in the shape of a cross. Thus armed, a cavalier carried at once with him the emblem of his faith and the instrument of his valour; and if mortally wounded on the field of battle, he could, like Bayard, kneel and pray before the emblem of the crucifixion." Here are likewise some swords of immense length, made at Rome, and consecrated by the pope, who sent them to be used in the crusades against the Saracens.

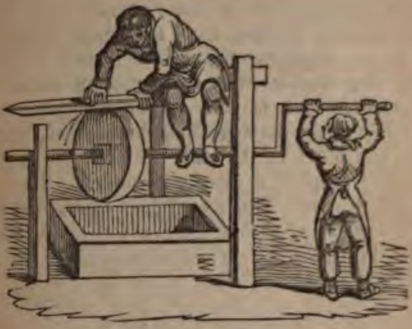
Of the very early manufacture of arms in this country we have no direct information; as, however, our warlike ancestors must have perceived how indigenous to their soil were two of what would always be deemed its noblest products, namely,—

—— "Man and steel, the soldier and his sword,"

so it is not likely that the produce of iron mines, so early discovered, would be exclusively devoted to the arts of peace. It is singular that the historians of the two most famous modern seats of the manufacture of edged instruments should respectively have found themselves compelled to rest upon mere probability, the claims of those two places to be regarded as engaged at an early era in the fabrication of arms, notwithstanding that the antiquity of their connection with the working of iron is indisputable.

With reference to the present famous metropolis of British sword cutlery, Hutton, its local historian, says: "As there is the highest probability that Birmingham produced her manufactures long before the landing of Cæsar, it would give pleasure to the curious enquirer, could he be informed of her size in those very early ages; but this information is for ever hid from the historian and the readers." With respect to another town, not less celebrated for its steel works than the last mentioned, Hunter remarks, "of the manufacture of arms at Sheffield we have no direct information. All the articles enumerated in the ordinances for the government of the cutlers of Hallomshire, and in the later act of incorporation are instruments of peace. And yet in an age when there was so large a demand for weapons of that description, which could be conveniently made along with what are known to have been among the manufactures of Sheffield, it is probable enough that her artists might be employed in their fabrication." The subjoined delineation of two men employed in giving an edge to a sword is curious, exhibiting what in all

Fig. 21.



probability was the common construction of grinding machinery about 1000 years ago. The original of this rude sketch is in an old psalter, written and illuminated by Eadwine, a monk, about the time of king Stephen; the book is in the library of Trinity College at Cambridge.

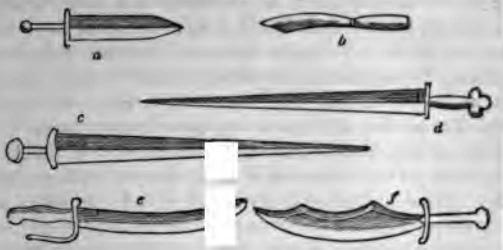
From ancient drawings, it appears, that in these very early times the blades of swords, instead of being polished upon a wheel covered with leather and emery, as at present, were placed upon a bench or board, and furbished by hand. In France a sword-cutler is still called *fourbisseur;* and the French familiarly say of two persons who are extremely intimate, "*Ces gens sont tête-à-tête comme des fourbisseurs;*" meaning that, like sword-cutlers (who used to work sitting closely opposite to each other), they are putting their heads together.

Tacitus states, in his life of Agricola, that the Romans found the aborigines of Britain not only armed with scythe-chariots, and spears of various kinds, but likewise with most formidable swords. "The Britons," says Tacitus, "who were possessed at once of bravery and skill, armed with huge swords and small bucklers, quite eluded our missive weapons, or beat them off; whilst of their own they poured a torrent upon us, till Agricola encouraged three Batavian cohorts and two of the Tungrians, to close with the enemy, and bring them to an engagement hand to hand; a mode of fighting very familiar with those veteran soldiers from long practice, but to the enemy very uneasy and embarrassing: for the swords of the Britons, which are so large and blunt at the end, are unfit for grappling, and cannot support a close encounter." The broad, blunt-ended, scythe-like sword just mentioned was no doubt a weapon of ancient date among our Pictish ancestors: the same instrument continued to be in use even with the Saxons, who, as we have already seen, derive, according to Verstegan, their appellation from the description of swords used by them; "which," says that author, "are called ꝺeaxeꞅ, or ðeaxen from ꝺaıꞅen, a scythe; because these swords have the edge the contrary way." The Saxons ultimately relinquished the use of the weapons thus termed, substituting in their stead long straight swords doubled-edged, and which they called *brands*, the word brand having long since become, among English writers, the poetical synonyme on a sword.

Very similar to the last-mentioned weapons were the great swords of the Normans, generally about three feet and a half or four feet long, double-edged, and sharp-pointed. In the "ordinance for arms" of that period it is said, "*uniquisque*, habeat cultellum." The cultellum is supposed to have been a sort of knife or dagger. The annexed figures are derived from Strutt, who himself copied them from ancient manuscripts.

Fig. 22. *a*, a dagger; *b*, a knife; *c* swords; *e* and *f*, short crooked swords.

Fig. 22.



Not unlike the ancient beaxer, only smaller, the more modern instrument called the falchion, o the French faulx; it is often used to defend a bre or prevent an enemy from scaling the walls of a fo tified place. This weapon is said first to have been resorted to with particular success when Louis XIV besieged Mons; and, on the surrender of that town, he besiegers found large quantities of scythes in the garrison.

The modern military sabre appears to have been derived partly from the faulx and partly from the cimeter. It is a sword with a very broad and heavy blade, thick at the back, and a little falcated, or crooked, towards the point: it is generally worn by the heavy cavalry and dragoons. The grenadiers belonging to the whole of the French infantry are likewise armed with sabres. The blade is not so long as that of a small sword, but it is nearly twice as broad. Among the British cavalry the sabre has mostly taken place of the old "broad sword;" the latter instrument, however, is still in use with some regiments of Highland infantry, having itself supplanted the great two-handed claymore so famous in Scottish history. This ponderous weapon appears to have had the blade three feet seven inches in length, two inches broad, and double-edged; the handle fourteen inches, with a plain transverse guard of twelve inches; the whole weighing six or seven pounds. The claymore was one of the original weapons of England; and the figure of one of them accompanied the effigies of a soldier found among the ruins of London, after the great fire, in 1666. The clumsy rusted weapon exhibited among the curiosities of Westminster Abbey as the "sword of king Edward," appears to have been an instrument of this kind, if its antiquity be admitted.

Every one has heard of the noted Andrew of Ferrara, whose name and personal identity have almost merged in the designation of the weapon called after him an "Andrea Ferrara." This celebrated individual was formerly considered to be the only man in Great Britain who knew how to temper a sword in such a way that the point should bend to touch the hilt and spring back again uninjured. He is said to have resided in the Highlands of Scotland, where he employed many workmen to forge his swords, spending all his own time in tempering them. This operation he performed in a dark cellar, the better to enable him to perceive the effect of the heat, and, probably, as a more effectual screen to his own secret method of tempering.

The sword which is at present generally worn by British officers is, what is called in military language, a long cut and thrust. It is an imitation of the sword most commonly used in the Austrian service; and was introduced into our regiments during the last war. It is not, however, considered to be so conveniently used by us as it is by the Austrians. On this subject James, in his "Military Dictionary," pertinently observes, that the Austrians have this sword "girded round their waists so that it hangs without any embarrassment to the wearer, close to the left hip or thigh; whereas, with us, it is suspended, in an awkward diagonal manner from a cross-belt over the loins, and is scarcely visible in front, except occasionally, when it is drawn or gets between the officer's legs, and sometimes trips him up when off duty. We could exemplify our ideas upon this subject by various known occurrences, such as the sword being suspended so much out of the grasp of the wearer that his right hand has appeared to run after the hilt, which has as constantly evaded its reach by the left side bearing it off in proportion as the right turned towards it; by officers being reduced to the necessity of applying to their serjeants, &c., to draw their swords: but it is not our wish to turn any regulation into ridicule. It is, however, our duty, and the duty of all men who write for the public, to point out practical inconveniences," &c. Our author then adds:—"Perhaps it may not be thought superfluous on this occasion to remark, that the sword ought not to be considered as a mere weapon of offence or defence in an officer's hand; for, unless that officer should be singly engaged, which scarcely ever happens upon service, the very notion of personal safety will take his mind off the superior duty of attending to his men. Officers, in fact, should always bear in mind that they are cardinal points which direct others. Their whole attention should be, consequently, paid to their men, and not the slightest idea must interfere with respect to themselves. We are, therefore, convinced, with due deference to the superior judgment of others, that the swords of infantry officers, and of the staff in general, should be of the small sword kind; sufficiently long to dress the leading files, &c., and extremely portable." The price of this regulation sword, or *epée d'ordonnance*, as the French call it, with spring shell and embossed blade, is commonly about three guineas.

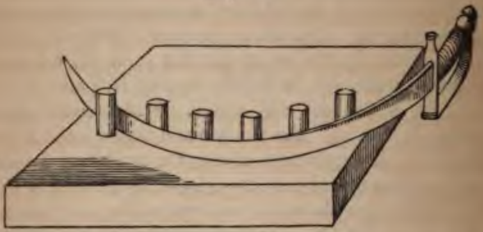
To the wearing of the sword belong the scabbard or sheath made of black leather or sheet steel polished; the belt by which it is suspended, which is worn either over the right shoulder or round the waist; and the knot or tassel of crimson and gold which adorns the pommel. This knot, although mostly for ornament, was intended to sling the weapon upon the wrist during the scaling a breach or boarding a vessel, when it might be necessary to use the hands without sheathing the sword.

It was since the Revolution that the sword trade flourished in England. Macpherson, in his " Annals of Commerce," mentions, under the year 1689, that, on the breaking out of king William's war against France, a company of sword cutlers was erected, by patent, for making hollow sword blades, in the county of Cumberland and the adjacent counties, for the use of the army. But though they were enabled to purchase lands, to erect mills, and to receive and employ great numbers of German artificers, yet they did not succeed. The first patentees, therefore, sold or assigned their patent to a company of merchants in London; who thereupon purchased, under that patent, to the value of 20,000*l.* *per annum* of the forfeited estates in Ireland. But the Irish parliament, in the reign of queen Anne, knowing they had purchased those lands at very low rates, would not permit them, in their corporate capacity, to take conveyance of lands, lest they might have proved too powerful a body in that kingdom. This obliged them to sell off their Irish estates, which put a period to the corporation. Yet a private copartnership of bankers in London, possessed of their absolute charter, retained the appellation of the Sword Blade Company till after the year 1720; they have, however, been long since broken up.

The manufacture of swords for the British service, and for exportation, has long constituted one of the staple trades in the populous town of Birmingham. The material out of which the blade is wrought should be cast steel, of the very best quality, and every process in the preparation of which has been conducted with the greatest care: of this material, besides the amount prepared in this town where it is worked up, many tons of the metal are annually sent from the forges of Sheffield, in what are called *sword moulds*, being a form of the bars peculiarly suited to the sword smiths. These moulds are then heated in the fire, and drawn out upon the anvil, much in the manner of large blades in general, — two men, a maker and a striker, using their hammers so as to give alternate strokes: the tang is of iron, and is, therefore, welded to the blade during the operation of forging. When the blade is required to be concave on the sides, or to have a reeded back, or some similar sort of ornament, it is hammered between steel bosses or swages, as the workmen term them. The blade is then hardened in the usual manner, by the smith heating it in the fire until it becomes worm red, and then dipping it, point downwards, in a tub of cold water. It is tempered by drawing it through the fire several times, until it exhibits a bluish oxydisation along the surface. In this state it is set or twisted into shape, by placing it in a sort of fork upon the anvil, and wrenching it, by means of the tongs, in the direction required to correct any degree of warping which may have been contracted during the hardening. The grinding of a sword is performed upon a stone having either a flat or a fluted surface, according to the kind of blade to be ground; by this operation the blade of a sword, as is the case with the web of a saw, loses much of its uniform elasticity; the temper, however, is presently restored by slightly heating it in the fire, after which it is glazed with emery, and, if for a fine instrument, polished with *crocus marti*, after the manner of a razor blade. It is now, if found perfect, ready for the hilt or handle, which is composed of a variety of substances; as ebony, fish skin, ivory, and, occasionally, still more precious materials. The guard, which admits of considerable diversity of form, is sometimes of iron; most commonly of brass, gilt; and, in some superb and costly articles, of silver and gold.

As so much is presumed to depend upon the goodness of a sword, every blade is submitted to a series of tests, much more violent than any service to which it is likely it can ever be really submitted. For instance, the point of a stout cavalry sabre, being placed against a pin in a board, containing six or eight spike nails, inserted at distances so as to form the segment of a circle, the blade is bent until it comes in contact with the spikes when the flexure towards the middle amounts to six or seven inches from a line drawn from the point to the hilt.

Fig. 23.



The point of the sabre is then placed upon a board, from which an upright piece rises, forming together a test-frame somewhat in the shape of an inverted F (thus Ⅎ): the hilt is then pressed down until the blade bend away from the upright piece about five inches, the amount of flexure being indicated by a projecting peg in the front of the frame. The sabre is likewise tested by striking it on both sides, as severely as possible, upon a stout table; and, afterwards, by smart strokes of both back and edge upon a block kept for the purpose. A sword that has sustained this fourfold ordeal will not be very likely to give way under any usage to which, as a hand weapon, it may be subjected.

The test to which the celebrated "Toledo blades' were submitted at the manufactory on the Tagus, when visited by Mr. Inglis, in 1830, is thus described:— "The flexibility and excellent temper of the blades is surprising: there are two trials which every blade must undergo before it be pronounced sound,—the trial of flexibility, and the trial of temper. In the former, it is thrust against a plate in the wall and bent into an arc at least three parts of a circle: in the second, it is struck edgeways upon a leaden table, with the whole force which can be given by a powerful man holding it with both hands. The blades are polished upon a wheel of walnut-wood, and are certainly beautiful specimens of the arts."

In the British manufactures, the blades are frequently fluted, and etched in the manner described in the article on razors; sometimes they are embossed, or ornamented with figures executed in a sort of relief by means of chisels and punches, so as to produce a rich and beautiful effect.

Among the ancient methods of beautifying swords and similar articles, that called damasking, or more commonly damascening, was the most famous: it consisted in inlaying the steel with different metals; and is supposed, from its appellation, to have been first practised at Damascus. "Damasking," says M. Savary, "partakes of the mosaic, of engraving, and of carving. As to the mosaic, it hath inlaid work; as to engraving, it cuts the metal, representing divers figures; and, as in chasing gold and silver, is wrought in relievo. There are two ways of damasking: the one which is the finest is where the metal is cut deep, with proper instruments, and inlaid with thick gold and silver wire; the other is only superficial. In the first, the incisions are made in the dovetail manner, that the gold and silver wire which is forcibly drove in may be firmly fixed. In the other, having heated the steel till it becomes of a blue or violet colour, they hatch it over and across with the knife, then draw the design or ornaments intended with a fine brass point or bodkin; which done, they take fine gold wire, and chasing it according to the figure designed, they carefully sink it into the hatches of the metal, with a tool suitable to the occasion."

The celebrated Italian artist, Benvenuto Cellini, whose memoirs, written by himself, are, as Horace Walpole said, "more amusing than a novel," states that he had, at one time, a strong inclination to cultivate this branch of art, so different from the rest of the goldsmith's business. He was led to form the desire, on seeing some little Turkish daggers, the handles of which were of steel, as well as the blades; and even the scabbards, he observes, were of the same metal. "My own performances, indeed," says the ingenious Florentine, "were much finer and more durable than the Turkish, for several reasons: one was, that I made a deeper incision in the steel than is generally practised in the Turkish works; the other, that their foliages are nothing else but chichory leaves, with some few flowers of echites: these have, perhaps, some grace, but they do not continue to please like our foliages. In Italy there is a variety of tastes, and we cut foliages in many very different forms. The Lombards make the most beautiful wreaths, representing ivy and vine leaves, and others of the same sort, with agreeable turnings highly pleasing to the eye. The Romans and Tuscans have a much better notion in this respect; for they represent acanthus leaves, with all their festoons and flowers winding in a variety of forms; and amongst these leaves they insert birds and animals of several sorts, with great ingenuity and elegance in the arrangement."

The bayonet, said to derive its name from Bayonne in France, is a kind of triangular dagger made with a hollow handle or socket, and a shoulder, to fix on the muzzle of a musket. At first the bayonet was made flat in the blade, not unlike a large carving-knife, and fitted with a round handle, so as to push or screw into the nozzle of the piece; in which case the soldier could not use it till he had fired: at present, the firing takes place with the bayonet fixed on the end of the barrel by means of a socket; so that the individual is instantly ready to act against an enemy's horse as with a pike. Grose mentions an instance of the consternation into which, for a moment, a part of the British army was thrown during one of the campaigns under William III. in Flanders, when the French unexpectedly fired upon them with fixed bayonets,—a novel mode of attack at that time. The introduction of the bayonet has been alternately attributed to the people of Malacca and the fuzileers of France, who were made a body of royal artillery. To a successful management of this weapon, M. Folard attributes, in a great measure, the victories gained by the French in the seventeenth century; and to the neglect of it, and trusting to their fire, the same author attributes most of the losses sustained by that nation in the succeeding war. At present, the bayonet is given to every infantry regiment, and it has become proverbially terrible in the hands of the British soldiery. Bayonets for the service are exclusively manufactured at Birmingham; the blade or dagger part is made of good steel carefully tempered; and the hollow socket and shoulder of the best iron. The whole is tested by striking the point smartly upon a block of wood.

There is little to be added to this chapter, in which, without going deeply into the subject, the author has embraced all the prominent points. Amongst the finest specimens of swords and daggers, we must regard those in the Indian collection of the Exhibition. These were all manufactured from the Indian "Wootz" already described and damascened, or *watered*, in a very beautiful manner.

CHAP. V.

FIREARMS.

EARLY NOTICES OF HAND-GUNS.—MATCH-LOCKS, WHEEL-LOCKS, AND PISTOLS. — MUSKETS. — MUSKET-REST. — SPANISH BARRELS. — INTRODUCTION OF GUN-TRADE TO BIRMINGHAM. — MARKING AND PROVING GUNS. — FORGING GUN-BARRELS. — PATENT SKELPS. — MESSRS. JAMES AND JONES'S PATENT. — ENGLISH AND INDIAN TWIST BARRELS. — STUB BARRELS. — BORING GUN-BARRELS. — BREECHING AND STOCKING GUNS. — BURNISHING AND BROWNING BARRELS. — RIFLES. — FRENCH AND ENGLISH MUSKETS. — EXTENT AND CELERITY OF FIREARMS AT BIRMINGHAM. — GUN-LOCKS. — SAFETY LOCKS. — PERCUSSION PRIMING.—REVOLVERS.

IT is a remarkable fact, that notwithstanding the substitution of cannon for some of the more ancient instruments of warfare must have so totally altered the various modes of military attack and defence, nevertheless the very era of the introduction of these formidable engines appears to be involved in absolute obscurity. Since, however, such is the uncertainty which attaches to the invention of heavy ordnance, the effects of which must necessarily have been so signal, we are by so much the more prepared to expect that the date of the origin of the smaller firearms will be placed in proportionate uncertainty. Beckmann supposes that the use of gunpowder itself first became known in Europe in the thirteenth century—about the time, indeed, when the methods of preparing the various sorts of Greek fire began to be lost; nor does it seem improbable that the idea of employing the more powerful of these compositions in projectile engines may have originated from witnessing, in the first instance, the common effect of both combustibles upon being inflamed in such cylinders as might happen to be employed in those close sieges, when fire, though not balls, was commonly enough emitted. These fire cylinders, which became the archetypes of the first artillery, were composed of iron strips placed together longitudinally, and firmly hooped with stout iron rings; cannon thus constructed are still to be seen, preserved as curiosities in European armories. It will easily be supposed, either that the charges introduced into such guns must have been lighter than those now in use, or that mischief from the bursting of the piece must frequently have happened: balls, however, generally of stone, and of a very large diameter, appear to have been shot from this apparently frail kind of ordnance with considerable success; at least, this is a received opinion, though stones were frequently thrown with catapultæ and other engines.

The earliest intimations of the unquestionable use of cannon are generally admitted to belong to the annals of the fourteenth century. It has been said that the English army used four pieces of cannon at the battle of Cressy, in 1346. What sort of guns they were, which were used in these instances, we are not told; they may have been pillars of brass, cast hollow, or even the hooped cylinders of iron rods already mentioned,—most likely the latter.

The idea of rendering portable, and of exploding in the hand, an engine constructed on the principle of the cannon, could not be expected very obviously to present itself even to a military mind, and therefore the first indications of the use of firearms occur long after the introduction of great guns. Two things would have to be considered in attempting the construction of a portable gun: in the first place, to make it as much lighter than an ordinary cannon as might be deemed consistent with safety and effect; and, secondly, to discharge it by the most manageable process: the union of these desiderata appears first to have been secured in the ancient but necessarily clumsy arquebuse. The first portable firearms were discharged by means of a match, which in course of time was fastened to a cock, for the greater security of the hand while shooting. In a warrant of Richard III. we find mentioned, "28 hack busses, with their frames, and one barrel of touch-powder." We likewise, about the same period, meet with "cross-bows of steel," the strings of which were detained and released by means of a trigger; which contrivance is supposed to have suggested the origin of our common gun-locks, and was first applied to the effecting a contact between the fire and the priming in the old matchlocks.

Afterwards a firestone was screwed into the cock, and a steel plate or small wheel, which could be cocked or wound up with a particular kind of key, was applied to the barrel. This "firestone" was not at first of a vitreous nature, like that used at present for striking fire, but a compact pyrites, or marcasite, which was long distinguished by that name. But as an instrument of this kind often missed fire, a match or fusee was for a long time retained along with the wheel, until men, observing the tendency of the friable pyrites to efflorescence, affixed a vitreous stone to the cock of the lock, resembling, on the whole, that universally in use, until a recent chemical discovery so generally superseded the flint itself.

In Germany, these arms were called *büche, hackenbüchse,* and *arquebuse;* the first of these names having, in the opinion of Beckmann, arisen from the oldest portable kind of firearms having some similarity to a box. "The hakenbüchsen," says that author, "were so large and heavy, that they could not be supported in the hand; it was, therefore, necessary to rest them on a prop called *bock,* or a buck, because it had two horns, between which the piece was fixed with a hook that projected from the stock." A figure and description of the *hackenbüchse,* the *bock,* the *wheel,* and *key,* may be found in *Histoire de la Milice, par Daniel,* printed at Amsterdam in 1724. And at Dresden there is still preserved an old *büchse,* on which, instead of a lock, there is a cock with a flint stone placed opposite to the touch-hole, and this flint was rubbed with a file until it emitted a spark. From the passages of writers, collected by Daniel, it is concluded that these *hakenbüchsen* with a wheel were invented in Germany towards the beginning of the sixteenth century.

Pistols, which were also at first fired with a wheel, are supposed to derive their appellation from *Pistorium*, a town in Tuscany, where they were first manufactured previous to 1544, in which year the REITERS, a description of German horsemen, were armed with them, and distinguished in military language as *pistoliers*. De la Noire, who served under the emperors Francis I. and Henry II., says that the Germans first employed pistols. Daniel mentions, that he saw an ancient pistol, which, except the ramrod, was entirely of iron. In the singular old Highland pistols, some of which exhibit such beautiful workmanship, the stock is generally of metal, and the butt end so shaped, that the pistol, when fired off, can be used as a very serious weapon at close quarters. The Highland pistol, although not used by any of the British regiments, is still worn by every person who wishes to be considered fully dressed and accoutred in the ancient garb. Mr. Gleig observes *, that " the year 1471 is remarkable for the introduction into this country of the hand-gun, the rude forerunner of the present firelock. To Edward IV. and a corps of 300 Flemings, with whom he landed at Ravenspurg in Yorkshire, were the English indebted for their earliest knowledge of this weapon, though it came not into general use for some years afterwards. It was a cumbersome shapeless machine, of very small bore, and discharged in the most awkward manner, which, besides carrying to less than half the distance of a long bow, occupied a very long time in loading. We cannot, therefore, wonder that a people so expert in archery should have treated it for a while with absolute contempt; indeed, we hear no more of it from the day of its arrival till the siege of Berwick in 1521. Even then, however, hand-guns were far from superseding the ancient national weapon of the English yeomen; and it was not till the time of Henry VIII. that the improvement in their construction rendered them comparable, as implements of annoyance, either to the long or the cross bow." Our author elsewhere adds, "that specimens of every kind of fire-arms known in this country since the date of the siege of Berwick in 1521 are to be seen in the Tower of London."

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* BRIT. MILIT. COMMANDERS, vol. i. Cab. Cyc.

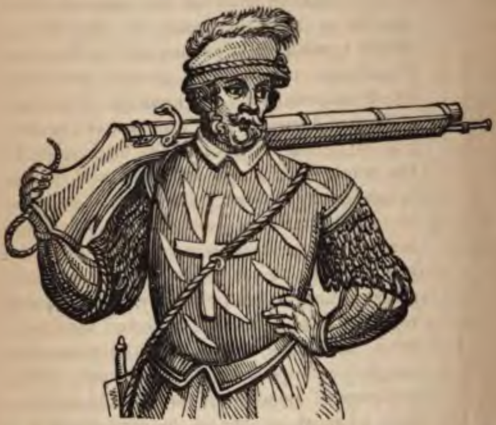
The musket, the most serviceable and commodious firearm used in the army, is said first to have made its appearance at the siege of Rhege, in the year 1521. Beckmann supposes that muskets received their name from the French *mouchet*, or the Latin *mouchetus*, which signifies a male sparrow-hawk. This derivation he thinks the less improbable, as it is certain that various kinds of firearms were named after ravenous animals; such, for example, as *falconet*, an ancient 1½ pounder. He proceeds, "that the lock was invented in Germany, and in the city of Nuremberg, in 1517, has been asserted by many, and not without probability; but I do not know whether it can be proved that we are here to understand a lock of the present construction. In my opinion, the principal proof rests on the following passage from an unprinted chronicle by Wogenseil:— 'The firelocks belonging to the shooting tubes were first found out at Nuremberg, in 1517.' It is certain that, in the sixteenth century, there were very expert makers of muskets and firelocks; for example, George Kühfuss, who died in 1600, and also others, whose names may be seen in Doppelmayer. I must not omit here to remark, that many call the firelock the French lock, and ascribe the invention to these people; yet as, according to Daniel's account, the far more inconvenient wheels on pistols were used in France in 1658, it is probable that our neighbours, as is commonly the case, may have only made some improvement in the German invention. In the history of the Brunswick regiments, it is stated that the soldiers of that duchy first obtained, in 1687, flint-locks, instead of match-locks. In old arsenals and armories, large collections of arms with the wheel are still to be seen. Major-general von Trew and Mr. Oivenus had the goodness to show me those still preserved in the arsenal at Hanover. Those which

I consider as the oldest, had on the barrel the figure of a hen with a musket in its mouth, because, perhaps, they were made at Henneberg. A pistol of this kind was entirely of brass, without any part of wood, and therefore exceedingly heavy. On the lower part of the handle were the letters J. H. Z. S., perhaps John duke of Saxony. A piece with a wheel, which seemed to be one of the most modern, had on the barrel the date 1606." There is a short thick firearm used in the service, called the musketoon, the bore of which is the 30th part of its length: it carries five ounces of iron, or seven a half of lead, with an equal quantity of powder. According to Strutt (*Manners and Customs of the English*, vol. iii. p. 91.), the archers and the henchmen, or men with axes, were, in the reigns of Henry VII. and Henry VIII., constantly intermixed with the gunners, musketeers, or, as Holinshed and some other chroniclers call them, harquebussers and pikemen; but, during the reign of queen Elizabeth they do not seem to have made any considerable figure, and in the days of James I. we hear no more of them: but the pikemen were continued down to a much later period; and the pikes then used form a considerable part of the small armory exhibited in the Tower of London, which must have fallen under the notice of most persons in the metropolis.

The musketeers, even in the time of Henry VII., and more particularly in the reign of his son, constituted a considerable part of the army; and, during the reign of James I., they with the pikemen formed the whole; for muskets were then used by the horse as well as by the foot soldiers. From that time English archery may be said to have been no longer in use. The following is the upper part of a figure, copied from a book in the Cottonian library, and exhibits a man with the hand-gun or musket on his shoulder, as in use in the reign of Henry VIII. (*Fig.* 24.)

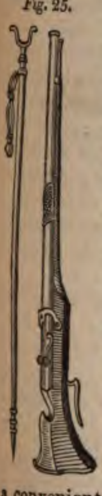
The priming was laid in the hollow at the side of the lock, exposed uncovered to the weather, which, when damp or rainy, would of course prevent the explosion of the gun, and render it useless. And John Bingham, an author who regrets the decay of archery, bears witness, that even in the more improved state of the musket, as in the reign of James I., it was subject to the same inconvenience; "for," says he, "in raine, snowe fogges, or when the enemy hath gained the wind, muskets have but small use." He declares that much time was necessary for their charging; "while," says he, "the musketeer takes down his musket, *uncockes* the match, *blows*, *praynes*, *shuttes*, *castes* off the pan, *castes* about the musket, *opens* his charges, *chargeth*, *drawes out* his skowring sticke (or ramrod), *rammes* in the powder, *drawes out* again, and *puts up* his skowring sticke, *lays* the musket on the rest, *blowes* off the matche, *cockes* and *tries* it, *gardes* the pan, and so *makes ready*; all which actions must necessarily be observed, if you will not fail of the true use of a musket."

Fig. 24.



The foregoing figure not only exhibits the musket of the sixteenth century, but likewise the match, and the method of holding it in the hand. Of this match, which was prepared so as to burn very slowly, every soldier carried a lighted piece with him, which, when used, was put into the cock, somewhat as we now put the flint, so that, by pulling the trigger, it was forced by means of a spring into the pan, and communicated the fire to the priming or powder laid therein. The rest mentioned above, and called *bok* by the Germans, was a staff about the length of the firearm, sharp at one end and forked at the other, as in the annexed cut.

Fig. 25.



It was a necessary part of the musketeer's equipage: when about to fire, he thrust the rest into the ground, and laid the musket between the branches while he took aim; this, but for the rest, he could not have done, on account of the weight of the musket. The rest, awkward and cumbersome as it must have been, was not given up without reluctance; because, besides being used as a support for the gun, it was also easily convertible in cases of emergency into a formidable pike. The rest is still generally used in shooting with the duck gun, which frequently weighs at least fourteen pounds, and sometimes upwards of twenty, and carrying from three to six ounces of shot. As, however, wild-fowl are often found in situations where water abounds, they are approached by means of a boat, having a convenient support for a very large fowling-piece.

Spain, once noted for its manufactures in iron, was famous for the excellence of its firearms. The author of "Wild Sports of the West" says,—"Spanish barrels have always been held in great esteem, as well on account of the quality of the iron, which is generally considered the best in Europe, as because they possess the reputation of being forged and bored more perfectly than any others. It should be observed, however, that, of the Spanish barrels, those only that are made in the capital are accounted truly valuable.

"They are proved with a treble charge of the best powder, and a quadruple one of swan or deer shot. At Madrid, and throughout all Spain, the manufacture of barrels is not, as in this and most other countries, a separate branch of the gun-making business; but the same workmen make and finish every part of the piece.

"Almost all the barrels made at Madrid are composed of the old shoes of horses and mules, collected for the purpose. They are all welded longitudinally; but instead of being forged in one plate or piece, as in other countries, they are made, like the English twisted barrels, in five or six detached portions, which are afterwards welded one to the end of another, two of them forming the breech, or reinforced part of the barrel."—"To make a barrel, which, rough from the forge, weighs only six or seven pounds, they employ a mass of mule-shoe iron weighing from forty to forty-five pounds; so that from thirty-four to thirty-eight pounds are lost in the heatings and hammerings it is made to undergo before it is forged into a barrel."

James, in his "Military Dictionary," says that the Spaniards were the first who armed part of their foot with muskets. At first they were made very heavy, and could not be fired without a rest: they had match-locks, and did execution at a great distance. These kinds of muskets and rests were used in England so late as the beginning of the civil wars. Musketeers, when on a march, carried only their rests and ammunition, and had boys to bear their muskets after them. They were very slow in loading, not only by reason of the unwieldiness of their pieces, and because they carried their powder and ball separate, but from the time required to prepare and adjust the match: so that their firing was not nearly so brisk as that of modern troops. Afterwards a lighter kind of match-lock musket came into use; and the soldiers carried their ammunition in bandeliers, to which were hung several little cases of wood, covered with leather, each containing a charge of powder: the balls they carried loose in a pouch, and a priming-horn hanging by their side. These arms, towards the beginning of the last century, were universally laid aside in Europe, and the troops were armed with firelocks. The firelocks were formerly three feet eight inches in the barrel, and weighed fourteen pounds: at present the length of the barrel is from three feet three inches to three feet six inches, and the weight of the piece only twelve pounds.

They carry a leaden bullet of which twenty-nine make two pounds; its diameter is $\frac{11}{20}$ths of an inch, the bore of the barrel being only about the 150th part of that diameter wider, because if the shot only just rolls into the barrel that is sufficient.

The fabrication of firearms is one of the most extensive and important of the manufactures of this country into which metal enters. The seat of this amazing staple trade is at Birmingham, which may not only be designated the armory of Great Britain, but even of Europe, and, in some sense, of the whole world; for there is probably no place, however remote, to which British enterprise has carried a knowledge of the deadly effects of powder and ball, where the gun-makers of that flourishing town might not recognise their workmanship.

The introduction and establishment of the Birmingham gun-trade are thus succinctly described by Hutton, the local historian:—"Tradition tells, that king William was once lamenting, 'that guns were not manufactured in his own dominions, but that he was obliged to procure them from Holland, at a great expense, and with greater difficulty.' Sir Richard Newdigate, one of the members for the county, being present, told the king 'that genius resided in Warwickshire, and that he thought his constituents would answer his majesty's wishes.' The king was pleased with the remark, and the member posted to Birmingham. Upon application to a person in Digbeth, whose name I have forgotten, the pattern was executed with precision, and, when presented to the royal board, gave entire satisfaction.

Orders were immediately issued for large numbers, which have been so frequently repeated, that they never lost their road; and the ingenious artists have been so amply rewarded, that they have rolled in their carriages to this day. Thus, the same instrument which is death to one man is genteel life to another!" The same authority adds, with characteristic quaintness, — "It seems that the word 'London' marked upon guns is a better passport than the word 'Birmingham;' and the Birmingham gun-makers have long been in the habit of marking their goods as being made in London. I am afraid this cannot rest on any better grounds than expediency, as it deviates a little from the direct line of right."

In 1813, a bill was introduced into the House of Commons, the object of which was to oblige every manufacturer of firearms to mark them with his real name and place of abode. The Birmingham gun-makers took the alarm; petitioned the house against the bill; and thirty-two gun-makers instantly subscribed 650*l.* to defray the expense of opposing it. They represented that they made the component parts of the London guns, which, in fact, were only put together and marked in the metropolis. The petitioners were successful; and soon afterwards, government authorised the gun-makers of Birmingham to erect a proof-house of their own, with wardens and a proof-master; and allowed them to stamp on their guns the ensigns of royalty. All firearms at present manufactured in Birmingham and its vicinity are subjected to the proof required by the Board of Ordnance; the expense not to exceed 1*s.* each piece; and the neglect of proving is attended by a penalty not exceeding 20*l.*

An ordinary musket passes, during the process of manufacture, through a variety of hands, aided, of course, in some of the heavier operations by the powerful application of millwork. The material for the ordinary barrel is first reduced to what is called a *skelp*, which is a plate of iron formed to the proper size and substance by cutting or rolling; in this state it is ready for welding, which is the next operation. Until the year 1811, or thereabouts, these skelps were generally manufactured by means of the forge hammer; but, during that year, a patent was granted to John Bradley, a Staffordshire iron-master, for making them by rollers instead of by hammering. The rollers first used for this purpose were about fifteen inches' diameter, and grooved on the surface. These grooves, instead of being equal in depth and width throughout, are cut in such a manner as to receive the bar or piece when four inches wide through its whole length, and yet to produce a skelp gradually tapering from that width to two inches and a half at the other end. According to the patentee, the advantages of this method of manufacturing skelps are, that the barrels made from them turn very sound and clear, and are free from greys or flaws; when welded, they grind and bore much clearer than hammered ones; the pure metallic particles, being compressed by the rollers both edgeways and flatways at the same time, cohere more closely together; nor are the skelps so liable to veins or flaws as those which are edged up in a less hot state under a forge hammer.

In the welding of gun-barrels, three hammermen are usually employed; the maker, who manages the heat, and directs the strokes by means of a small hammer, and two strikers with heavy hammers. When a common musket barrel is made, the maker inserts the thicker end of a skelp in the fire, and having heated it to a sufficient redness, he withdraws it and places it over a hollow in the face of the anvil; his two assistants then strike it with the edges of their hammers, so as to turn up the sides of the metal: one of them then adroitly places within it an iron mandrel, which he holds firm, while his fellow laps over, or closes up the parallel edges to a certain extent. The mandrel being withdrawn, the forging is returned to the fire, and heated to a welding glow; it is then again placed upon the anvil, the mandrel re-inserted, and the maker and strikers, applying their hammers, firmly incorporate the two sides together. The like operation having been performed throughout its length, the whole becomes a compact tube of iron. The mandrel, upon which the hammering takes place, does not at once extend through the barrel, but only the greater part of that distance; another and shorter mandrel being inserted at the opposite end, by means of which the "heat" or mass is more successfully managed on the anvil. In order to prevent, as much as possible, the hands of the forgemen from being burned, hoops, five or six inches in length, and made of pieces of old barrel, are slipped over the mandrels to the upper end against a knob or turn-up, which is left on the mandrel for the purpose of allowing it to be drawn out of the barrel by means of a stroke or two with the hammer. The mandrel, during this moulding and welding of the barrel, becomes, of course, itself red-hot, and requires to be repeatedly quenched during the operation.

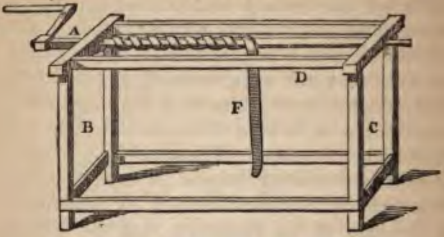
In 1811, Messrs. James and Jones, gun-makers of Birmingham, obtained a patent for what they designate "an improvement in the manufacture of barrels of all descriptions of firearms and artillery." The instructions relative to welding, as entered in their specification, are as follows: — "Take a skelp or piece of iron adapted for the purpose of making barrels for muskets or any other firearms; let it be turned or brought into a form proper for welding; heat it in an air or reverberating furnace, or a hollow fire, so constructed as to give a regular welding heat to one half of the barrel at a time, or to any other given portion desired; when it is heated to a proper welding heat, the mandrel or stamp is to be expeditiously put into it, and the barrel placed or held on an anvil or swage grooved to fit the form of it; upon which several hammers, worked by any mechanical power, are caused to strike with great velocity upon the portion of the barrel desired to be welded; and when sufficiently welded and hammered, the mandrel is to be quickly struck out before the hot barrel has time to contract too close or adhere upon it. The number.

weight, and velocity of the hammers may be varied according to the description of barrel desired: but, for musket-barrels, which are generally from three feet three inches to three feet six inches long, when it is wished to weld them at two heats, the patentees recommend six hammers, which hammers should be ranged in a straight line, side by side, as true and as close together as they will work free, and covering a space in length of about twenty inches, and in width four or five inches; they should work very true upon the anvil, and may fall either together or alternately; the faces may either be level, or hollowed out a little in those parts which fall upon the barrel when welding. The advantages of the aforesaid method of heating barrels in a hollow fire, and welding them by hammers worked by machinery, are, in the opinion of the patentees, that the articles are manufactured much sounder, more expeditiously and accurately than by the old process; and especially that cinders, ashes, and dirt are prevented from getting into the inside of the barrels or between the welding seam or joint, which not unfrequently happens in the common method, and in consequence of which the metal bores black and unsound."

The twist barrels, as they are called, are used for the most curious and expensive kinds of guns and pistols. The manner in which these are prepared, and which gives them that peculiar appearance which is so much admired, is also attended with the more real advantage of rendering them much less liable to burst. The metal for these turned barrels is selected from iron and steel of peculiar character. Scrap iron, and horse-shoe nails, being tied into a bundle are welded into a flat bar. A bundle consisting of bars of iron and of steel placed alternately, or two of one and one of the other, is again welded into a single bar. The workman takes one of these strips, and, after heating it in his hearth, places one end of it in a loop on the mandrel A (*fig.* 26.) which is fitted into the iron frame B C, and parallel with which lies the bar D. Then turning the handle

E, the metal band F, prevented by the bar from springing up, is wound upon the mandrel to a sufficient extent in length, after which the mandrel is easily withdrawn, leaving the coil itself in a state to be welded. The welding is performed in a similar manner, and with the same tools as in the former case, only that instead of lapping the edges together lengthwise upon the anvil, the twisted article is *jumped* or bounced upon the floor, by which process the edges of the metal throughout the heliacal suture are driven together, and the welding successfully effected; the operation being completed by the further heating and hammering of the barrel.

Fig. 26.



The peculiar appearance of some of the most expensive gun-barrels manufactured in this country is an imitation of a process long known in India, and depending upon the same principles as those to which the Damascus blades are indebted for one of their rarest attractions. The patterns on the finished gun-barrels vary with the number of bars of iron and steel introduced. The order in which they are arranged, and also to their being either placed together plain or twisted. If a right-hand twist is given to one bar and a left-hand twist to another, a pattern differing materially from that obtained by a single twisted bar and a plain bar, is produced. In this way the gun maker has it in his power to vary, almost infinitely, the ornamentation of the gun-barrel. Captain Bagnold says, that the gun-barrels made at Bombay in imitation of those of Damascus, so much valued by the Orientals for the beauty of their twist, are manufactured from iron hoops obtained from European casks, mostly British. The more these hoops are corroded by rust, the more acceptable they are to the workmen; should there be any deficiency of this necessary oxidation, they are regularly exposed to moisture until they are sufficiently prepared for welding. Being cut into lengths of about twelve inches, they are formed into a pile an inch and a half high, laying the edges straight, so as not to overlap each other: a larger piece is then fitted so as to return over each end, and hold the whole together in the fire. The pile is then heated, and drawn out into a bar of about one inch wide and one-third of an inch thick: it is doubled up in three or more lengths, and again drawn out as before; and this operation is repeated, generally to the third or fourth time, according to the degree of fineness required. The bar is then heated about one-third of its length at a time, and being struck on the edge, is flattened out in the contrary way to that of the stratification. This part of the operation brings the wire or vein outwards upon the strap. The barrel is then forged in the usual way, but much more jumping is used than in the English method, in order to render the twist finer. The most careful workmen always make a practice of covering the part exposed to the fire with a lute composed of mud, clay, and the dung of cows or horses, in order to guard against any unnecessary oxidation of the metal. When the barrel is complete, the twist is raised by laying the barrel from one to five days either in vinegar or a solution of the sulphate of iron, until the twist is raised: this process is called the wire twist. To produce the curl, the bars or straps are drawn out into lengths about three quarters of an inch square, and twisted, some to the right and others to the left; one of each sort is then welded together, doubled up, and drawn out as before. The experience of the workmen enables them to produce any intricacy of twist by this drawing out, doubling, and twisting.

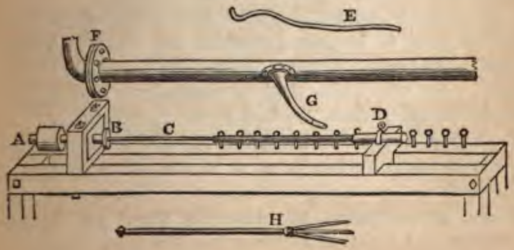
Sometimes, to save trouble and economise iron thus prepared, the artist will rough-file an English barrel, weld a strap of Damascus iron spirally round it, or several are laid longitudinally, and welded on. A native artist never works with coal. Charcoal from light woods forms his only fuel. In making the sword blades there are, according to Captain Bagnold, several methods adopted: some make a pile of alternate layers of hardened steel, with powdered cast iron mixed with borax sprinkled between each layer. These being drawn out to a length exceeding by one third that of the intended blade, are doubled up, heated, twisted, and re-forged several times. The twist is brought up in the same way as that in gun-barrels. Some swords are forged out of two broad plates of steel thus prepared, with a narrow plate of good iron welded between them, leaving a portion of solid steel of considerable depth for the edge. Others prefer making them of one plate of steel with a lamina of iron on each side to give strength and toughness. Swords of this description, the narrator states, were tempered in the presence of himself and his brother with considerable effect, in the following compound: — The blade was covered with a paste formed of equal parts of barilla, powdered egg-shells, borax, salt, and crude soda. It was heated to a moderate red heat, and just as the red was changing to a black heat, it was quenched in spring water. According to the information given by a workman to Captain Bagnold, Damascus still obtains steel from the upper part of the Deccan, where the material is called *fonlode hind*, or Indian steel, of which there are great quantities, but little or no demand for it. The same authority states that the damasque, or joar, is natural to this steel, and is raised by immersing it in an acid solution.

The Birmingham workmen, in preparing the material for stub-barrels, usually cut up strips of iron and steel, with large shears, into bits like two inch nails. These bits are then arranged and intermingled in a variety of forms, by filling them compactly into a hoop or ring, in a manner similar to that which is common among the blacksmiths for using up old horse-shoe nails. The lump is then formed into a bloom in the furnace; after which it is welded and drawn out under the rollers or hammer into the strips already described. The metals, when properly mixed, exhibit a beautiful appearance on being treated with an acidulated liquor, after which the barrel is finally got up.

Being finished at the welding shop, the barrel is carried to a workman, whose duty is carefully to exmine it, and, without again heating, to set it perfectly straight, by means of a few strokes with his hammer upon an anvil. He likewise tries its soundness, by placing one end in a bucket of water, and sucking, with his mouth at the other, until the water fill the barrel: by this means if there be any crack or flaw, however produced, which extends through the substance of the barrel, it is presently detected by the appearance of the moisture on the outside. When this happens to be the case, the article is returned to the forger, and the fracture closed by re-welding.

When straightened, and found perfect from the anvil, the barrel is in the next place transferred to the boring mill. The boring-bench (*fig.* 27.) is composed

Fig. 27.



of two stout beams of timber, somewhat more than twice the length of the largest barrel intended to be bored thereon. At one end of the bench, and supported by proper puppets, runs the spindle with an appropriate pulley, A, by means of which through a strap, its motion is derived from the moving power; and upon the nose of the spindle is fitted an iron chuck, B, having in its centre a square hole for the reception of the drill, C. This drill is a steel rod, having at one end a square knob for insertion in the chuck, and being at the other end of an angular form for several inches, not unlike the bit of a common fire poker. The angular edges are maintained by means of the grindstone in as sharp a state for cutting as possible. The barrel intended to be bored is fastened at the breach or stouter end by means of a strong screw and staple, D, to a wooden plug, fitted to slide between the beams of the bench throughout the entire length.

Along the surface of the farther beam is placed a row of stout pikes at a short distance from each other; the following is their use: — The workman taking in his hand the iron lever E, and placing the hooked end against one of the most conveniently situated spikes, he bears against the barrel, and by this means urges the operation of the drill inside with a force proportionate to the pressure of the lever.

In consequence of friction the barrel becomes excessively heated during what is called the rough boring, and it is necessary to cool it by bringing upon it a constant stream of cold water. This is done by attaching to the pipe F, which is placed over the bench, a little
flexible hose, G, by means
a constant stream of water the
barrel near which the drill is outside
of the barrel is then levelled b on to the
grindstone, the workman allowing rticle to roll
slowly through his hands, so as to pr ent every part of the surface successively to the stone. The stones used by the gun grinders are generally about six feet in diameter and eighteen inches across the face.

Gun-barrels, instead of being ground on the outside upon a stone, are sometimes turned at a lathe, being *pushed* for that purpose upon an iron mandrel, the ends of which run in collars or journeys, steel cutters, as the barrel revolves, working successively upon its surface. These cutters are fixed in rests made to slide slowly along two or more stout bars placed in a direction parallel to the line of the article to be turned. James and Jones, of Birmingham, already mentioned, had a patent for turning barrels by this method. Besides the advantage claimed for this invention, on the ground that one skilful foreman with his assistant may with ease attend four or more turning machines, and thus finish a greater number of barrels ready for filing; they are likewise said to be produced much more perfect and true than can be accomplished by grinding. Ground barrels are very frequently unequal sided, one side of the barrel, in some instances, being nearly twice as thick as the other, and having twice the substance of metal in it; whereas by turning the barrels they are made more equal, and consequently much stronger with the same weight of metal. The patentees considered that another advantage arose from the application of the lathe by rendering unnecessary the use of expensive grindstones, from which dangerous accidents sometimes happen. The grinding of the barrels, which is at all times a laborious, dangerous, and unhealthy business, was in this case superfluous. There can be no doubt but that machine turning, such as is here alluded to, must be comparatively a safe, easy, and healthful occupation, though it is very questionable whether, either on the score of economy or utility, it possesses any really valuable advantages over the common method of levelling barrels upon the grindstone.

The barrel is afterwards *fine-bored,* upon a bench similar to that already mentioned. The drill, however, in this case, is ground in such a manner that only one of the angles can cut, the edge being kept to its work by means of two strips of soft wood attached, H. As the barrel does not become particularly heated by friction during this operation, and as the force required to make the drill, or more properly the rounder, cut, is inconsiderable compared with that which is necessary in rough boring, both the water pipe and the lever irons are dispensed with: instead of the latter, the barrel is urged upon the borer by means of a weighted rope passing over a pulley under the bench, and attached to the sliding plug already described. Ingenious or interested gun-makers have at different times advocated the boring of the barrel a little wider at the breech or at the muzzle, or in some other part, under the idea of making it kill more closely. There does not appear, however, to be much confidence placed in any advantage derivable from these modes.

The barrel having been tapped at the stouter end, and being fitted with the breech screw, is sent to the proof house, from which, if it stand the test, it is returned with the government mark. A gun-breeching till of late years was, what it still remains in muskets used in the army, simply a plug screwed into the end of the barrel, so as to reach to the touch-hole, and sometimes filled with a small groove to hold a greater depth of powder near the touch-hole. The first improvement was to bore a hole down the centre of this plug, which was made somewhat stout and deep for the purpose, and then to bring the touch-hole to it in a right angle. This is generally the principle of the chamber-plug, which has been superseded by the solid breeching of the celebrated Mr. Nock, and the improvement of the still more celebrated Mantons. In this plug the breeching is literally solid, with the exception of the touch-hole, and a small perforation, which, when the piece is charged, becomes filled with powder, the ignition of the main body of the charge taking place in a part of the barrel considerably removed from the touch-hole.

The next process is that of stocking. The right performance of this operation is a matter of great importance in the estimation of first-rate sportsmen, though much less thought of in the routine manufacture of common guns. Colonel Hawker says, "the length, bend, and casting of a stock must, of course, be fitted to the shooter, who should have his measure for them as carefully entered in a gun-maker's books, as that for a suit of clothes on those of his tailor. He has then only to direct that his guns may be well balanced, to do which the maker will introduce lead, in proportion to their weight; so that, on holding each of them flat on the left hand, with the end of the feather-spring about half an inch from the little finger, he will find a sufficient equilibrium to make the gun rest perfectly steady on the hand." Stocks are most commonly of walnut wood; but in some of the finer pieces American maple is used, which, from the peculiar character of the grain, presents, on being stained and polished, a most beautiful appearance. Preparatory to being fitted to the stock, the barrels are passed through the hands of a workman, who files and shapes the breech so as to suit it for insertion in the wood. The stocking-room is fitted with vices, planes and chisels, and gouges, brace and bits, rasps, files, and, in fact, the tools usually found in a cabinet-maker's shop. The stock being already sawn into shape, the workman with great expertness and accuracy, by means of his tools, ploughs out the gutter for the lodgment of the barrel, and cuts the recess for the lock, fitting both with so much precision, that the metal parts adhere with tolerable firmness in their places to the wood without any fastenings. The piece in this state is carried to another workman, by whom it is shod with brass, the trigger guard and other brazen ornaments let into the wood, and every article bored and fastened with appropriate screws. The whole is now taken to pieces, the brass work filed all over, and got up to a polish by means of buffing or burnishing, and the barrels are finally sent to be finished.

When barrels are required to be bright externally, they are commonly transferred, in the state last mentioned, to women who file them all over with smooth files, and afterwards operate upon them with a burnisher of hard polished steel, so as to produce a considerable lustre of surface. The maintaining this beautiful polish on the barrel of his musket long constituted no inconsiderable portion of the labour of the soldier when not upon duty: to him who has merely to make his appearance on parade once or twice a day this attention is no great matter; but to the man on actual service, the time and toil required to perform the task alluded to constitute a harassing addition to the fatigues and dangers of the field. This was so sensibly apparent to the duke of Wellington during his Peninsular campaign, that his grace dispensed the men under his command from the performance of this irksome attention, by allowing all the musket barrels to be browned; and hence, when a soldier spake to his piece under the somewhat endearing appellation of "Brown Bess," he meant something more than a mere compliment of attachment to his firearm.

For browning iron the following method has been published: — ℞ Nitric acid, half an ounce; sweet spirits of nitre, half an ounce; spirits of wine, one ounce; blue vitriol, two ounces; tincture of steel, one ounce. These ingredients are mixed, the vitriol having been previously dissolved in a sufficient quantity of water, to make, with the other ingredients, one quart of mixture. Previously to commencing the operation of browning a gun-barrel, it is necessary that it be well cleaned from all greasiness and other impurities, and that a plug of wood be put into the muzzle and the vent well stopped. The mixture is then to be applied with a clean sponge or rag, taking care that every part of the barrel be covered with the mixture, which must be exposed to the air for twenty-four hours, after which exposure the barrel must be rubbed with a hard brush, to remove the oxide from the surface. This operation must be performed a second and a third time (if requisite), by which the barrel will be made of a perfect brown colour. It must then be carefully brushed and wiped, and immersed in boiling water, in which is held in solution a quantity of alkaline matter, in order that the action of the acid upon the barrel may be destroyed. The barrel, when taken from the water, must, after being rendered perfectly dry, be rubbed smooth with a burnisher of hard wood, and then heated to about the temperature of boiling water. It will then be ready to receive a varnish made of the following materials:—Spirits of wine, one quart; dragon's blood, pulverised, three drachms; shell lac, bruised, one ounce; and after the varnish is perfectly dry upon the barrel, it must be rubbed with the burnisher to give it a smooth and glossy surface.

While the barrel is undergoing this final process, the stock with all its furniture is likewise being finished; the wood is stained and varnished, and the iron burnished; after which, the piece being completely screwed together, is ready for delivery at the warehouse. Muskets, when sent abroad, are packed in cases, containing twenty-five pieces each.

Besides the ordinary musket, there has been of late years introduced into the military service a more curious and murderous firearm called the rifle, and by the French, in whose hands it was formerly turned to dreadful account, *arquebuse rayêr*, its use in war being to shoot officers and others picked out of the ranks by the keen eye and unerring hand of men trained to the duty, and designated riflemen. Humanity shrinks at the idea of thus selecting, with personal precision, and for instant death, even the enemies of our country, and surely the practice ought to be condemned and abandoned by every civilised nation. The weapon itself, which has usually a small bore, owes its peculiarity to certain lines or exiguous canals within the barrel running in a vermicular direction, and more or less numerous, or deeply indented, according to the fancy of the artificer. With respect to the word itself, James, in his Military Dictionary, observes, that it does not appear to bear any other analogy to our common acceptation of the verb, than what may be vulgarly applied to the common practices of riflemen. It is, on the contrary, more immediately connected, in sense and signification, with an old obsolete word to *ray*, to streak, which comes from the French *rayer*. The rifle possesses over the common barrel many advantages, attributed to the threads or rays with which it is indented. The threads are sometimes cut in such a manner, that the line which commences on the right side of the breech, terminates on the left at the muzzle, by which means the ball acquires a rotatory movement, revolving once and a half round its own axis before it quits the piece, and then boring through the air with a spiral motion. It is well known that cannon balls, and shot out of common barrels, are impelled in a different manner.

According to the same authority, the rifled barrels used by the Americans, during the war of independence, contained from ten to sixteen rays or threads ; some had as few as four. Some persons have imagined that those of sixteen rays were the best, from a supposition that, by the air collapsing in the several grooves, the ball obtained more velocity. Mr. Robbins, however, seems to differ in opinion, particularly with respect to the depth of the grooves. He observes, in his tracts on gunnery, that whatever tends to diminish the friction of these pieces, tends, at the same time, to render them more complete ; and, consequently, it is a deduction from hence, that the less the rifles are indented, the better they are ; provided they are just sufficient to keep the bullet from turning round in the piece. It likewise follows, that the bullet ought to be no larger than to be just pressed by the rifles ; for the easier the bullet moves in the piece, supposing it not to shift its position, the more rapid and direct will its flight be.

It is necessary that the sweep of the rifles should be, in each part, exactly parallel to each other, otherwise the uniformity of their effect would not only be disturbed but counteracted. Some of the rifles of the backwoodsmen or squatters of Indiana, are upwards of four feet long in the barrel, and carry so small a shot, that sometimes upwards of 100 of them go to the pound. The Tyrolese likewise use rifles of exceedingly small calibre, and, like the Americans, are very expert marksmen. A writer, in the United Service Journal, who appeared to understand the subject, recommended, some time ago, that a musket considerably lighter than that at present in use should be adopted by the British infantry. After stating the undeniable fact, that there is no country where the manufacture of arms is so well understood as in England, and where the beauty and excellence of the guns for sporting are consequently unrivalled, the writer alluded to thus proceeds:—"When a sportsman examines his arm, the first thing he does is to satisfy himself that the action of the lock is quick and easy; that the piece shoots with the necessary accuracy; that it comes cleverly up to sight; that the bend, length, and thickness of the stock suit him exactly; that the weight is precisely what he requires it to be, and that it is well poised in the hand. If the arm is deficient in any of these particulars, he immediately rejects it as unserviceable. Let us now try the musket by this standard, and we shall find it deficient in every particular. These may seem trifles to many, to me it appears that the fate of kingdoms very much depends upon them; and that the most *extravagant economy* that has ever been thought of, is that of giving inferior arms to troops even upon the score of profit and loss. A member of the Chamber of Deputies lately produced an English and a French musket, to show the superiority of the latter; and, although it seems to have caused some surprise to see such a weapon in such a place, his conclusion was quite correct. It is not enough that we should be equal to other nations in the arming of our troops, we ought to be decidedly superior to them, because we have the means of being so; and the British musket, in the present state, can be regarded in no other light than as a reflection upon the age in which we live."

Perhaps the foregoing conclusion is somewhat too sweeping; but let us hear what is the remedy proposed.

"Under these circumstances," proceeds our military authority, "as the principles upon which a soldier and sportsman act are precisely the same, I conceive that they should be armed as much alike as circumstances will permit. I would, therefore, give to the former a light percussion gun, thirty inches long in the barrel, and weighing from seven to eight pounds, which experience has proved to be the most handy for an ordinary-sized man. The calibre to be reduced to twenty-two balls to the pound, and loaded with a drachm and a half of the best cylinder powder; by which arrangement the soldier would fire three rounds instead of two, and carry 100 rounds of ammunition instead of thirty. The ramrod not to be turned in loading, but used as that of a rifle. Instead of a bayonet, I would recommend a very light rifle sword; for as soon as a bayonet is fixed, accuracy of firing is at an end. I am aware it will be immediately objected by many, that by shortening the musket the efficiency of the bayonet, that irresistible weapon in the hands of an Englishman, is at once destroyed. In reply to this objection, I may at once frankly state, that I have no great faith in the bayonet: to trust to the bayonet, instead of fire, is to go back to an age prior to the invention of gunpowder. Another objection may, perhaps, also be stated in reducing the calibre of the musket. The ball now used, of fourteen to the pound, will, no doubt, inflict a more severe wound than one of twenty-two: but we find, from experience, that sixty rounds of ammunition is not enough, and the soldier cannot carry more of that size. In skirmishing, it is fired away in an hour and a half; and at Waterloo some regiments had to stop their fire in the heat of the action. Even when a supply is at hand the difficulty of distributing it to troops in action is very great."

Scarcely any thing can more strikingly illustrate the vast extent of our local manufacturers, and the freedom of dealing in an article, upon the export of which the political existence of continental states, and even the security of our country might depend, than the gun trade of Birmingham. Whenever warlike movements are seriously contemplated abroad, the great Warwickshire workshop is resorted to, and customers are welcomed according to their means of payment. The arms which Holland and Belgium employed in the recent struggle,—or rather, perhaps, those that might have been required had the two countries been allowed to continue the contest,—were only not furnished by the Birmingham gunsmith because neither the Dutch nor Flemish agents could give that security for payment which was required. Poland, too, unhappy Poland! pending the struggle that *for the present* has decided the fate of that country, had its agents in Birmingham, with an order for 50,000 stand of arms; but the singularly novel and unsafe conditions required of the manufacturers,—namely, the safe delivery of the arms in Poland! stood in the way of a ratification of the contract. Attempts were made by parties to meet the emergency; and many cases filled with *iron piping* were arrested in transitu, the continental inspectors perceiving, at once, the difference of manufacture between tubes for the conveyance of gas or water, and those for the discharge of powder and ball.

Even the British government itself, if we may admit the authority of a Birmingham journal, has no objection, under certain circumstances, to resell arms purchased from Birmingham to other countries. It appears that, in November, 1830, the French government despatched agents to Birmingham, where they were led to understand they might, upon the instant, purchase from 400,000 to 500,000 stand of arms. The contemplated use of these arms was the equipment of the national guard. Upon enquiry, however, the French agents found they were mistaken as to the amount of ready-made muskets to be obtained in Birmingham; and were, in consequence, recommended by the manufacturers, to apply to the British government for assistance. Ever since the close of the war, a large depôt of arms had been established in the Tower; and it was known to some in the trade, that of this warlike stock the government were desirous to dispose. Accordingly, the French agents adopted this advice; and immediately entered into a negotiation with the English government. At first their application appeared to be decidedly successful; but subsequently, owing either to the unsettled state of Ireland, or the commotions and threatening prospects of our own country, the government declined to part with the arms, and the negotiation was abruptly broken off. This immediately led to a renewal of the correspondence with the Birmingham manufacturers; the principal agent, on the part of the French government, being no other person than Mr. Rothschild, the eminent capitalist and money-broker. The total number required by the French government was 140,000 stand of arms, part of which were manufactured by London houses. The whole of this contract was required to be completed in seven months.

The celerity with which firearms were manufactured, and the high prices paid to workmen in periods of excitement and demand, are strikingly illustrative of the perfection to which our countrymen have carried this branch of manufacture. At Birmingham, during the war, it was understood that they made a musket per minute, and the contract price at which they were supplied to the British government was 36*s.* each. A serious reduction, however, took place when peace came; so that the prices paid by the French, in the contract above mentioned, and which were considered liberal, were about 28 francs, or nearly 23*s.* each gun. For gun-locks, which towards the beginning of the previous year only 1*s.* 6*d.* each was paid, the manufacturers were glad at the end of 1830 to give 2*s.* 6*d.*

About the period in question, and when the French contract excited considerable attention, especially in connection with the report that the order was for 1,400,000 stand of arms, a London newspaper asserted that the Birmingham manufacturers would require fourteen years for the completion of so extensive an order. The journal whose authority is before quoted contradicts this assumption, and on satisfactory data; for it appears, by reference to a table in Mr. Parsons's pamphlet on the manufacture of firearms, that, in the year 1813, there were fabricated in Birmingham, for the Board of Ordnance, not less than 320,643 stand of arms, and in 1812, 288,741. From the statement set forth in this pamphlet, from authorised returns, it further appears, that from the year 1804 to 1815, more than two-thirds of the firearms made for the Board of Ordnance, during the war, were made in Birmingham. Allowing for the reduction in the number of hands which has necessarily taken place within these few years, there is no doubt but at the present time the manufacturers of Birmingham could set up 200,000 stand of arms per annum, while those of London would produce from 80,000 to 100,000.

It will readily be conceived that the fluctuations consequent on such an important but variable trade must be productive of serious inconveniences to the workmen, and even to the town of Birmingham. Such is the fact; and, owing to the comparative extinction of the trade, since the close of the war, the operative departments have often been abandoned by the workmen, for other more certain and permanent sources of employment and subsistence. But when there has been any stir, as with the contract before mentioned, these men, elated by the temporary prospect, generally in numbers return to their old avocations.

As the bow and the javelin, those ancient weapons of British warfare, have been entirely superseded in modern military science by the superior firelock musket, so the picturesque diversion of hawking, so distinguished in the field sports of our ancestors, has no less given way before the murderous fowling-piece of the modern sportsman. The high prices formerly paid by the gentry, for first-rate and perfectly-trained falcons, have now-a-days their counterpart in the sums expended upon prime guns by celebrated makers. Some of these pieces, as well from the

Birmingham as the London makers, exhibit a beauty of material, a perfection of workmanship, and an exactness in their powers of execution, that must astonish every person not conversant with such matters. The most famous metropolitan gunsmith is Manton, who holds a place in the estimation of sportsmen like that of Andrew of Ferrara among the amateurs of swordmanship; the names of the artists in each case having passed into a synonyme, indicative of the perfection of the articles made, or reputed to be made, by them.

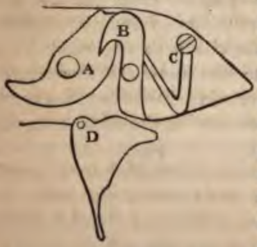
The most interesting writer on the subject of fowling-pieces, and all matters connected therewith, is colonel Hawker, already mentioned, accounted one of the best shots in England; and who, in his "Instruction to Sportsmen," has touched upon all points relating to guns and shooting, in a manner which shows how thoroughly conversant he is with the subject. The colonel gives a list of upwards of fifty London gunmakers, from Mr. Joseph Manton, who charges sixty guineas for a gun, to others of less eminence; adding, however, with reference to the whole, that "guns of a common size are now brought to such perfection, that a person who is content with being tolerably well served can hardly go amiss in choosing his gunmaker."

Besides the numerous reputed manufacturers of fire-arms in London and Birmingham, there is hardly a town of any size in the kingdom that is without its gunmaker. These provincial artists, although not unfrequently individuals of first-rate ingenuity as workmen, never entirely fabricate the articles sold by them. Obtaining the barrels and the locks from the regular houses, the business of the country gunmaker is mostly to stock and finish the piece in a superior manner; and more especially to clean, repair, and alter the guns of gentlemen in his immediate neighbourhood. He is likewise a dealer in all the necessary accoutrements of the sportsman,—powder, shot, percussion caps, and so forth.

The manufacture of gun-locks is a separate branch of the trade, and gives employment to a vast number of hands, at and about Wolverhampton. Although those commonly in use in the military service exhibit the principle upon which the ordinary lock is constructed, there are numerous diversities in detail introduced by different gunmakers, some of which are the subjects of patents. The three prime conditions of a good lock, are, 1. that it works easily and efficiently ; 2. it should not be liable to go off at half-cock, or otherwise accidentally ; and, 3. that its discharging the piece, on pulling the trigger, should be certain. From the superiority of modern workmanship, there are few expensive locks, the mechanism of which does not admirably fulfil the first of these conditions ; complaints on this head are, therefore, exceedingly rare. As colonel Hawker observes, "Any comment on the perfection to which this part of a gun is now brought would be quite redundant. Notwithstanding, however, that almost every country fellow can turn out a tolerably well filed lock, yet few even in town have the knack of making the springs to go so pleasant to the touch, and (if I may use the expression) feel so oily, as those made by the two Mr. Mantons, Mr. Egg, Mr. Nock, and some few others ; I mean, that many, even of the best finished locks, have an unpleasant harshness, which is not only disagreeable to feel, but, by reason, not so steady to action." What had been gained by modern ingenuity, in the delicate operation of the lock, must, unhappily, have been altogether added to the amount of danger always inseparable from the use of firearms, were it not that the means of security, to an almost equal extent, have likewise been superadded to the latest improvements. The best known of those contrivances which have been resorted to, in order to prevent the accidental explosion of firearms, is the slide bolt, so commonly noticed in the best sort of pistols, and occasionally of guns also. This bolt, by means of an external knob moving over a groove in the plate of the lock, is made to pass through the tumbler of the cock inside, and in some cases through the tail of the hammer also ; thus preventing at once the piece from exploding, and powder being lost out of the pan. The bolt perfectly secures the lock from operation, while pushed forward; it requires, however, to be withdrawn previously to firing; a consideration which sometimes leads to omissions in restoring it, when the piece has been cocked without firing.

In 1804, Mr. Dodd, of Portland Place, London, received the silver medal of the Society of Arts for his improved gun-lock, constructed on a principle by which it is rendered so perfectly secure at half-cock as to preclude the possibility of its firing in that state, by accident, violence, or design; thus possessing all the advantages of stop or bolt locks, without their inconveniences or complicated construction; having, moreover, not one piece of machinery more than is used in the simplest form of locks. Other advantages claimed for this lock are, 1. that the more the trigger is pulled at half-cock, the more secure against firing the piece becomes; 2. the lock cannot possibly catch and stop at the position of half-cock, when passing from the whole cock, and thus miss fire,—a serious inconvenience in locks of the usual construction; 3. the improved lock is much less liable to be out of repair, as it possesses four times the strength of common locks where the latter are weakest, and equal strength in other parts. The following cut (*fig.* 28.) will convey a distinct idea of Mr. Dodd's improvement on the old lock:—A represents the tumbler, moving on the pivot of the cock; B the sear; C the sear spring; D the trigger. All the parts are in the position of half-cock. From the slightest inspection of the figure, it must be evident that, in consequence of the firm locking of the sear in the tumbler, the gun cannot possibly go off; and it is equally apparent, that any attempt to pull the trigger can only,

Fig. 28.



by pushing against the tail of the sear, render the chance of an explosion, as it were, still more impossible. When it is wished to put the gun in a position for firing, by pulling back the cock, the hooked point of the sear B will be placed in a little nick at the top of the tumbler A, and, consequently, the tail of the sear will be advanced so as to yield to the operation of the trigger, on almost the least possible pressure of the latter.

The discovery of a method of discharging firearms by means of an explosive mixture, so as to supersede the use of powder as a priming, has led to an alteration in the construction of gun-locks, hardly inferior in novelty to that which took place on the substitution of the modern flint for the ancient fire-match. In the improvement referred to, the pan which contained the prime powder, is superseded by a small upright nipple, or chimney, the perforation of which coincides with the touch-hole of the barrel. The cock in its action and general figure remains unaltered, except that, instead of the clamp-bits to hold a flint, it has a short snout adapted to fall exactly upon the top of the nipple already mentioned. To fire the piece, a little cap of copper, about the thickness of a small quill, and one eighth of an inch deep, containing within a drop of the preparation afterwards described, is placed upon the nipple; by a smart stroke with the hammer of the cock upon the capsule, the mixture instantaneously detonates, and communicates with the charge in the barrel.

Although the detonating locks have now so generally superseded the common locks in the fitting up of expensive guns, it is not uncommon for sportsmen to have duplicate locks of each construction, so as to apply the one or the other interchangeably and at pleasure.

Cannon are generally fired by means of a match, especially in the field; to the great guns, however, on board a man-of-war, is not unfrequently fitted a lock, the trigger of which is pulled by the aid of a rope attached thereto. A percussion lock for firing ordnance has been invented by captain Henry Dehnel, of the royal Hanoverian artillery. This lock consists of a hammer in the form of an S, or swan neck, one end of which works upon a steel pin in a joint attached to the cascabel or tail of the gun. This hammer is detained and liberated by means of a rope attached to its neck; and the exploding stroke takes place upon a small bridge, which is let into the vent field, and which receives the copper arm of a detonating tube. The advantages claimed for this lock, are, simplicity of construction, the ease with which it is fastened to the gun, the security derived from its position, and the fact of the vent remaining free, so that the piece can be fired without interruption, either in the ordinary manner or with the percussion lock.

As the discharging of fowling-pieces by an application of the percussion principle has now become almost universal among sportsmen, and as the same mode is largely adopted in the use of every description of guns, we shall close this article with an extract from a "Report on Fulminating Powders, capable of being used as Priming for Firearms, by MM. Aubert, Pélissier, and Gay-Lussac." This interesting article originally appeared in Annales de Chimie, Sept. 1829, and the translation below quoted was printed in the Repertory of Arts the year following. A great number of powders which fulminate by a blow are known; but with respect to their application to firearms, those of chlorate of potash and fulminating mercury alone deserve particular attention, the others presenting too many inconveniences or dangers in their preparation and employment.

Powder, with chlorate of potash, is an intimate mixture of sulphur, charcoal, and chlorate of potash. The sulphur or the charcoal may be suppressed on substituting inflammable substances, but the powder then loses more or less of its power. At the suggestion of Berthollet, the discoverer of chlorate of potash, the manufacture of this powder was begun in 1786, at Essonne; but an explosion, followed by the most serious accidents, soon caused it to be abandoned. This composition is stronger than the best powder made with saltpetre; it speedily renders the trial-mortar unserviceable, by enlarging the chamber, and producing deep cracks in it. Employed by M. Welter, at Meudon, to fill bombs, which he caused to explode buried in the earth, it constantly broke them into uniform pieces of the size of a chestnut, whilst the pieces of other bombs, filled with common powder, and placed in the same circumstances, were much less numerous.

The property which this powder possesses, of being inflamed by a blow or a stroke, determined its application, as priming, to percussion guns; but it soon gave place to fulminating mercury, on account of several inconveniences attending it, the principal of which are, to cause a great foulness, and to have a corrosive action on iron. Various methods have been tried to neutralise the effect of the acid; but the most successful results were accompanied by such a diminution of the explosive force of the mixture, as to have led to its discontinuance as a priming for firearms.

Howard's powder, or fulminate of mercury, is at present generally employed for the guns of sportsmen, on account of its easy inflammation, and its inaction upon iron. It is a salt formed of the suboxide of mercury, and a peculiar acid called fulminic, consisting of two atoms of cyanogen (nitrogen and carbon), two of oxygen, and two of the elements of water. Since the composition of this powder has been known, it has been named *fulminate of mercury*. When it detonates by a blow or by heat, the mercury and nitrogen are set at liberty in the state of vapour; and from the carbonaceous deposit observed on the surfaces on which it has been made to detonate, it is very probable that half the carbon which it contains forms, with the oxygen, carbonic acid, and that the other half is deposited or dispersed.

The fulminate, when dry, detonates very readily by a *blow* of iron upon iron, a little less readily by a blow with iron upon bronze, still a little less by that of marble on glass, marble on marble, or glass on glass; it inflames, however, with sufficient facility in these different circumstances. to be almost sure of causing the explosion at every blow. The blow of iron upon lead inflames it, but with great difficulty, and that of iron upon wood is quite ineffectual.

The fulminate always inflames easily by *friction*, especially by that of wood against wood. It detonates less readily by that of marble on marble than of iron upon iron, and lastly, of iron upon wood or marble.

The fulminate which has been pulverised detonates with more difficulty, particularly by friction, than that which is in crystals. Moistened with five per cent. of water, the fulminate loses a great deal of its inflammability: it detonates, however, with the blow of iron on iron; but the portion struck burns alone, and without flame, nor does it communicate inflammation to that which is not struck.

If the fulminate be mixed with ten per cent. of water, it will be still more difficult to inflame it. It disappears, however, by a blow of iron upon iron, but without flame and noise: the part struck *burns alone, and projects* the other. Moistened with thirty per cent. of water, it still detonates, sometimes under the muller (wood on marble), during the manipulations; but the detonation is partial, and is not communicated to the rest of the mass: the muller is merely raised under the hand of the workman. According to the new arrangements adopted in the manufactory of priming powders situated in the plain of Jory, near Paris, since the explosion which entirely destroyed it, more than 200,000,000 of caps have been manufactured at that establishment, without any other accident than a piece of marble broken under the muller, as above mentioned, More than 1,300,000,000 percussion caps are now made yearly in Europe, requiring 396,000 lbs. weight of copper.

The character of the powders eminently inflammable is to detonate at the moment of their inflammation, even when only very small quantities are employed, and to act on surrounding bodies as a moving power actuated by great velocity. The best made common powder is extremely far from having such a rapid inflammability as fulminate of mercury, and especially as fulminate of silver; and no firearms, loaded with either of these fulminates, with the same charge as common powder, can resist their explosive action, although the volume of elastic fluids produced in the first case is smaller than in the second. Whatever charge of the fulminate of mercury may be put into a firearm made with the known metals, it will speedily be destroyed; for during the charging of the primings or matches with the fulminate weakened with common powder, the punches of tempered cast steel, with which the powder is pressed to the bottom of the capsules, are speedily furrowed by the explosions which occur every moment, although the gases produced have a free passage by the sides of the punches. The report details a series of experiments which place in a striking point of view the rapidity of explosion and irresistible power of this singular composition.

The quantity of fulminating mercury necessary for a priming is so small, that it is in a manner unmanageable; and this circumstance naturally led to the expedient of mixing it with common powder, to increase the bulk of the priming: but this is not the chief advantage of the mixture. Pure fulminate of mercury communicates inflammation to powder but with difficulty, and at much smaller distances than when it is mixed with bruised or very fine powder: this is a consequence of the instantaneousness of its inflammation. If it is alone, the explosion is too rapid, and the heat is carried off too suddenly to explode the powder; but if it is intimately mixed with very fine powder, the latter is carried to the charge while in a state of ignition, and sets fire to it. In the trials of mixture of the fulminate with various substances, made rather with a view to preserve the priming from humidity than to change the composition of the powder, it was found that many were unfavourable to the explosion of the fulminate, although mixed with it only in very small proportions: such are oil, tallow, resin, and wax.

Of the different sorts of priming hitherto employed in France, there have been used, 1st, the fulminating powder in grain; 2d, the powder in pastilles covered with lead or paper; 3d, the powder in grains varnished; 4th, the waxed primings; 5th, the caps or capsules; and 6th, tube primings. The powder in grains is very dangerous, for the explosion of a single grain determines that of the whole mass. It is almost entirely disused. The other primings have not the same inconvenience, having a covering in common with those called waxed, and with caps, which are almost the only ones in use.

The waxed primings were in use with sportsmen when proposed by M. Vergnaud for the infantry. Every one contains three centigrammes (nearly half a grain English) of fulminate of mercury, and one centigramme of bruised gunpowder, and are enveloped with a coating of wax applied by hand, which defends them very well from the action of moisture, and prevents them from exploding simultaneously. They fix also very readily to the pan, and may be easily and safely carried, protecting them from the heat of the sun and of other bodies which might determine their agglomeration. They have the inconvenience of causing great foulness, and giving a little more smoke and smell than cap primings. Their present price in commerce is about seven francs per thousand.

The cap primings are most in use at present, and form at least 99 per cent. of the consumption: those for the guns of sportsmen contain in each priming 0·017 grammes of fulminate of mercury, mixed with six-tenths of its weight of bruised gunpowder. These primings very well resist the action of humidity, and take fire after several hours' immersion in water.

Their very regular and solid form allows of their being fixed on the chimney of the touch-hole by mechanical means, which will be very advantageous for military fusils. In the explosion, the copper cap is torn — sometimes divided and projected; but by hollowing the head of the percussion hammer, the copper is no longer projected except towards the ground.

The copper caps are made by means of a fly press with great rapidity. The primings sometimes take fire during the manufacture; but the inflammation communicates but very rarely to the small number of those under manipulation. They are easily carried, and without danger. Their present price in commerce is $3\frac{1}{2}$ francs per thousand.

Cast iron being comparatively a weak metal for resisting extension, such as that produced by the explosion of gunpowder, various attempts have been made to introduce wrought iron instead. Greater success has, however, attended the efforts which have been made to improve the metal. In Belgium they have prepared cast iron for guns with coke and wood. One of the guns cast from this metal stood 2,116 rounds, and then 3,647 rounds, without much injury to the touch-hole or vent; whilst one which had been twice "rebouched" stood 6,002 rounds without injury. Few guns will stand more than 800 rounds. We learn, however, that the guns on the English batteries at St. Sebastian were fired 2,700 rounds, but "you could then put your fist into the touch-holes."

Rifles, guns, and pistols, loading at the breech, have been lately introduced. The needle gun, as it is called, has the breech opened by merely turning down a lever. The cartridge, with a patch of percussion powder in the end, is then placed inside the breech, which is again closed, and the charge fired by pulling the trigger which projects a needle against the patch at the end of the cartridge. Colonel Colt's revolving chambers excited at the Exhibition much attention. In these pistols and rifles, when the hammer is down, it rests between two of the pillars, which prevents the breech from turning, and secures it from accident. At half-cock the breech is freed, and can be turned round by the finger for the facility of loading, which is very quickly done by means of a jointed ramrod, the upper part of which acts as a lever to force the lower part and the charge into the chambers. At full cock the breech is brought with a cap under the hammer, and each charge can be fired as rapidly as one can cock and pull the trigger.

CHAP. VI.

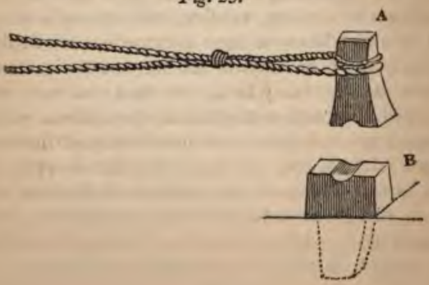
QUALIFICATIONS PROPER FOR A WHITESMITH.—FORGING, SWAGING, AND FILING.—APPARATUS FOR BORING SOLIDS AND CYLINDERS.—TURNING LATHES.—COMMON WHITESMITH'S LATHE.—DOG AND DRIVER, AND CHUCKS.—MAUDSLAY'S LATHE, CHUCK, AND REST.—TURNING TOOLS.—SLIDE LATHES.—VARIOUS METHODS OF PRODUCING SCREWS.—INSIDE SCREWS, OR BOXES. SAWING CAST IRON WHEN RED-HOT.—CUTTING HARDENED STEEL WITH SOFT IRON.

THE whitesmith, or *brightsmith*, as the term implies, is an artificer who makes and finishes articles chiefly in iron or steel with a bright surface, by means of the file and the turning-lathe, in contradistinction to the blacksmith, who furnishes the productions of his forge either in a rough state, as from the hammer, or, at most, as blackened over with smoke or pitch. Originally, the whitesmith fabricated many of those articles for domestic use, as fire-irons, fenders, grates, &c., which have since become objects of separate manufacture. A modern whitesmithery establishment generally comprises the ingenuity and conveniences requisite for the production of every description of work, from what is called blacksmithing in its lowest, to what is termed machine-making or engineering in its highest degrees. Hence, a first-rate whitesmith is not only required to understand generally the qualities of common iron and steel, and the methods of forging, welding, and otherwise working them; he must likewise have a competent knowledge of the principles of mechanical science, the laws and combinations of machinery in all the technical varieties of their application, and so much of mathematics as pertains to the accurate calculation and distribution of force, momentum, friction, &c., as may enable him to apply with success and economy all the understood theories of his business, and to direct him in the prosecution of new experiments.

He should likewise be a tolerable draughtsman; not only for the purpose of enabling him to comprehend and correct any plan that may be laid before him by his employers, but likewise to assist him in rendering intelligible to his workmen the designs of articles to be executed by them. Upon the possession of this latter talent a great deal occasionally depends; for it is easy to conceive how comparatively imperfect, without the assistance of drawing, must often be the verbal instructions communicated to the most intelligent working smith, even by an ingenious master; and, moreover, how much time and trouble may often be wasted in giving directly to iron the figure of the first crude idea as it rises in the mind, or even as it may have been perfected there — for only a very little experience is required to teach a man that certain pieces of work may appear to be very clearly laid down in the mind, though in the workshop they become of very difficult execution indeed.

The practical operations of the whitesmith may be divided generally into forging, filing, boring, turning, and screw-cutting. The hearth, anvil, and tools connected therewith, differ in no material respects from those found in the common blacksmiths' shops. A whitesmith, when working at the anvil, unless the piece under the hammer should be very light, is assisted by a striker, who, as usual, wields with wonderful precision a sledge hammer. To turn out, after this operation, a piece of work square and regular, and exactly of the

Fig. 29.

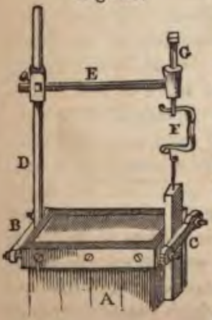


size required, is the pride of the workman. In forging round articles, such as bolts, axles, &c., the whitesmith makes use of swages: these consist of a piece of steel somewhat in the form of a hammer head, A (*fig.* 29.), having a hazel stick twisted round the upper part to hold by, and the face containing a groove suited to a corresponding hollow in the face of another and similar piece, B, placed in a hole in the anvil. In forging small spindles, the boss, or lower piece, is permanently fixed upon the anvil, and the upper one is made to rise and fall between two grooved uprights; so that the workman has only to strike the swage on the head, with a hammer in one hand, while he manages the heated spindle with the other. When the work is to have a collar or swell upon it, a ring of iron is either welded on, or the requisite swell is effected by means of a hollow in the groove of bosses or swages, similar to those above described. For the better management of very heavy articles, a crane is fixed in the workshop, the arm of which traverses between the fire and the anvil.

No small portion of the credit and success of a whitesmith depends upon his ability in using a file. There is no tool in the management of which so little dexterity is necessary; a good filer, however, is comparatively but rarely met with. The difficulty lies in finding united in the same individual what the workmen understand by *a true eye* and *a correct hand.* The secret lies in so applying the file that the surface of the work, when so intended, shall be perfectly straight and flat, in opposition to that convexity which more or less distinguishes all ordinary filing. Some adepts at their business will not only use the file so accurately that there shall be no convexity, but actually a concavity of surface, and that not merely on a large article, where the file being tapered may be supposed to describe the segment of a circle, but on small goods, where the effect must be referred to extraordinary precision of stroke. In smoothing the surface of very large articles, they are operated upon, while red hot, by what is called a float or rubber, being, in fact, a single-cut file about a yard in length, and stout in proportion, with a handle at each end, to be used by two men, in the manner of a cross-cut saw. The files used by the whitesmith upon cold work are mostly of the cross-cut description, and follow one another from the roughest to the smoothest sorts, the latter being often used to give a finish to the work, by being placed across it, and rubbed backward and forward, so as to strip it lengthwise: with the finest dead smooth files, oil is frequently used, though its application would entirely prevent the cutting of an ordinary rasp, by causing it to glide over the surface of the work.

In blacksmiths' work, the pieces that cannot be conveniently welded are generally riveted together by means of holes punched at corresponding distances through the materials. The whitesmith, on the other hand, mostly connects his work by the more accurate and neat method of screws, either inserted into the substance of the article, or passing through it, so as to be fastened by nuts on the side opposite to the screw heads; he is, therefore, provided with the requisite tools for boring holes of all sizes. This operation is commonly performed at the boring block, or boring *stoop*, as it is called in the North. *Fig.* 30. will render perfectly intelligible the following description:—A is a stout solid post of wood, fixed deeply in the ground, and rising about three feet above the floor; on its upper end is fixed a massy hoop or frame of iron, with four large screws, each furnished with nuts and washers, and projecting two and two in opposite directions; a strong bar of iron, perforated at each end, being fitted upon and allowed to traverse freely each pair of screws, B, C. These screws and cross-bars are designed to act as grips or vices, to detain on the one side the article to be bored,

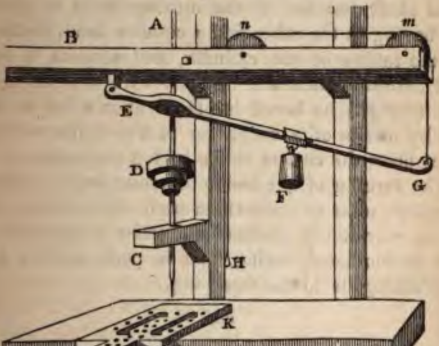
Fig. 30.



and, on the other, to support a stout stem or pole of iron, D, upon which is made to slide the arm, E, at the extremity of which a screw passes through a swell, so as to detain and keep to its work a drill, turned by means of the iron crank handle, F; the operation being very similar to that performed by the joiner when boring with a brace and bit. The point boring-iron or steel of the drill is well supplied with oil, that it may cut with the greater ease, and not become so hot as to soften it: cast iron is bored without any lubrication of the piercer. As the perforation advances, the drill is still urged downwards by means of the screw G, at the end of the arm E.

In boring large articles, a machine (*fig.* 31.) is used, to which motion is communicated by steam or other power, and the pressure upon the drill so regulated that the boring proceeds without requiring immediate attention.

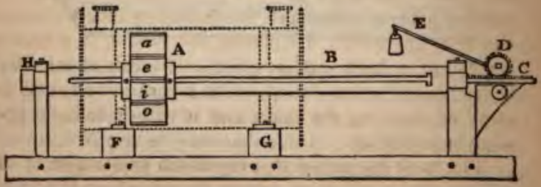
Fig. 31.



A is an upright rod or spindle of steel, about four feet in length, moving freely within bushes at B and C in the frame. At the lower end of this spindle is inserted the drill, of any size that may be required, about the middle is the pulley D, over which passes a strap to connect it with the moving power; and above the pulley there is a swell, upon which, by the bearing of the lever E, a pressure is maintained sufficient to keep the drill constantly at work. This lever is of iron, six or seven feet long; the force with which it operates is regulated by the position of the metal weight F. To the loose end of the lever is attached a cord G, which, running over the pullies *m n*, terminates in a bob, H: by means of this string the lever is easily raised, and the drill released from the work; the work itself is attached to the cast-iron plate K, which is perforated for that purpose, and, by means of screws and grooves, admits of being fastened in the most suitable position on the bench. In some boring apparatus, the drill is pressed to its operation upon the substance to be bored, by means of a rack and pinion connected by a rod to the lever, instead of the weight F. Iron pump barrels, and other cylinders of the smaller sorts, which are required to be smooth and true inside, are bored by means of a stout metal shaft attached to the turning lathe at one end, and having at the other end a circular head, nearly filling the calibre of the cylinder, and adapted to receive steel cutters, which are fastened with wooden wedges. The article to be bored is placed upon a bed or frame, and by means of a weight or rackwork is made to advance upon the cutters as the boring proceeds.

The turning of the inside of steam-engine and other cylinders, so as to make them perfectly true and smooth for the working of pistons and other purposes, is likewise denominated boring, and is performed on a principle analogous to the foregoing.

Fig. 32.



In the sectional view (*fig.* 32.), A is a stout trundle or head of wood, its size nearly equal to the inside diameter of the cylinder to be bored: *a, e, i, o,* are steel cutters, of which there are eight, placed in grooves across the block, and fastened by means of wedges. This cutter block is constructed to slide upon the hollow cast-iron shaft B, along each side of which there is a longitudinal groove: so that, by means of a metal stopper inside, connected with the cutter-head by pins, the whole may be advanced or drawn back together. To effect this advance of the cutters, the rack C is passed down the hollow shaft, and, while one end bears against the stopper, the projecting portion is subjected to the operation of the pinion D, which is made to act by means of the weighted lever E. The cylinder, the figure and position of which are indicated by the dotted lines, is placed upon bearers F G, and fastened by iron straps or girders passing over it, and screwed down upon the bearers. Its position is so adjusted, by means of wedges and screws, that the cutter shaft is exactly parallel to its inner surface. From this description it will be perceived, that when the cylinder is thus firmly fastened down upon its bed, and the cutter tube made to revolve upon its connection with the prime mover at H, the rack bearing against the stopper inside will cause the steel cutters on the block now pushed forward to act upon the metal, and thus, as the motion continues, accurately to bore out the inside of the cylinder to the exact diameter of the cutters. When one set of cutters has been passed quite through, they are removed, and others in succession a little larger, introduced, until the requisite size, smoothness, and perfection of bore are attained. There are various other contrivances for boring cylinders; among the rest, one which, by placing the casting in a vertical instead of a horizontal position, allows the metal which is cut away during the operation to fall out at once, instead of clogging the cutters, as it will do sometimes in horizontal boring.

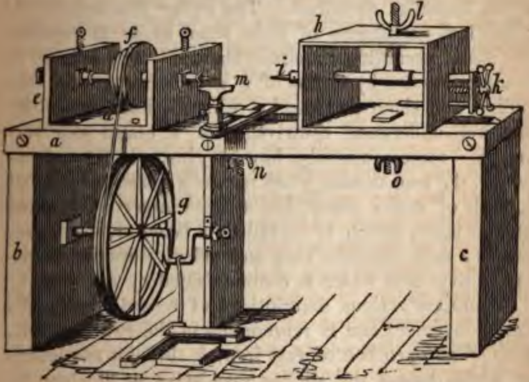
The most important and ingenious application of the whitesmith's skill, if we except the manufacture of large screws (which, however, depends upon the same principle), is connected with the art of turning; and perhaps there is no contrivance with which human ingenuity has aided the dexterity of the handicraftsman, more entitled to our admiration than the lathe, — especially when we take into the account all the improvements which this useful machine has undergone, from its simplest and most ancient form in the potter's wheel, to that adaptation of varied and complex mechanism by which not merely circular turning of the most beautiful and accurate description, but exquisite figure-work, and complicated geometrical designs, depending upon the eccentric and cycloidal movements, are daily produced in the workshops. The engine-turning operations of the whitesmith are mostly confined to the production of circular work; but in this, great precision of size and form is usually required, and not unfrequently considerable beauty is attained in the execution.

As there is no operation connected with the conversion of iron and steel, into the innumerable and complicated details of modern machinery, which is more in demand than that which is performed by the lathe; it was to be expected that a machine, the aid of which has become so vastly important, would itself receive a degree of attention corresponding with its relative consequence: such has certainly been the case. Lathes, or turning-engines, of all sorts, have not only been brought to a high degree of perfection, by and for all classes of the regular workers in metals, but they are likewise manufactured to a large extent for sale, either to suit professional turners or amateurs; and of the latter class, no small number are to be found in different parts of the kingdom. The lathes last alluded to are constructed upon a vast variety of models, either according to the fancy or ingenuity of the parties making them, or as suitable to the purposes for which they may be intended: some of them, as already stated, exhibit an indescribable complexity of parts and operation, and are calculated to produce results of singular delicacy, variety, and beauty.

As, however, the operation of turning, in its application to iron and steel, is one with which the whitesmith is largely conversant, even in the manufacture of lathes of all sorts, it will be proper to notice more particularly in this place the engines generally used by workmen of this class. By whatever means a substance capable of being cut can be made to revolve with a circular motion about a fixed right line as a centre of motion, in such a manner as that, by the application of a tool to any part of its surface, its inequalities shall be so removed, that every part of the circumference shall be equidistant from that centre — the idea of a turning lathe is produced. Although, as above stated, great diversity and complexity have of late years been introduced into the manufacture of the lathe, yet the machine for common purposes may be constructed in a very simple manner, as, indeed, we often find it to be in common whitesmiths' shops.

In *fig.* 33., *a* is the front portion of a strong bench or bed of wood, composed of two pieces, each six feet in

Fig. 33.



length, lying exactly parallel and at a small distance from each other, so as to leave an opening between them: they are firmly screwed together at the ends, and supported in a horizontal situation by the two uprights *b c*, which rise from the floor about three feet. *d* is a frame of cast iron, consisting of a bottom plate attached to the bench, and two upright ends or puppets which support the spindle. Through the back puppet *e* passes a stiff screw, the end of which contains a hole for the reception of the pointed end of the spindle. The other, or front puppet, is furnished with two hardened steel dies, fitted so as to form a collar in which the neck of the spindle works: these collars are made to pinch the spindle neck more or less closely by means of the regulating screw at the top of the puppet. The spindle itself is a steel bar, twelve inches long, and finished with a point at one end; the other end is exactly turned, so as to work steadily in the collar above mentioned, and finished with a swell or shoulder; it is likewise screwed inside and out at the end, the inside screw being intended to receive the centre bit, and the outer screw to carry the chuck hereafter described. The pulley *f* is usually divided into peripheries of three sizes, so as to regulate the speed according to circumstances. The spindle is made to revolve by means of a strap passing over this pulley, and about the wheel *g*, which is itself turned by the well-understood contrivance of a crank axle and treadle: more commonly, however, instead of this foot-wheel, the iron turner, when not in a situation to avail himself of steam power, has a much larger wheel fixed at a distance, which is turned by a labourer, by which means a more uniform slow and effective motion is obtained than that which is communicated by the foot.

There are various descriptions of centre puppets; a very convenient one is represented in the cut. It consists of an open box of cast iron, *h*, through the length of which passes the sliding mandrel *i*, at the end of which is inserted a steel point in a line exactly corresponding with a similar point in the nose of the lathe spindle. This mandrel, with another shorter and smaller for the purpose of steadying the horizontal motion, is fastened to a piece of iron, through which passes a screw with a cross head *k*, and by means of which the mandrel is advanced or drawn back; when in the right position, it is held firm by the operation of the screw *l*. The rest, *m*, is a piece of iron in the shape of a T, inserted in the upright cylindrical socket of an article which is contrived to slide along the surface of the bench, and to admit of being fastened in the situation required, by means of a headed screw passing down between the pieces of the bench, and carrying the grip *n*; the mandrel box *h* is rendered movable by an exactly similar contrivance, *o*.

When a piece of work is intended to be turned, say a mandrel or spindle, it should be forged as round and smooth as possible, by means of the bosses already described, and likewise be set, or straitened accurately, so as not to jump or swag in any part when made to revolve. In fitting it for the lathe, the exact centre at each end is found by means of a pair of compasses, and a small hole punched for the reception of the centre points. In this state, it is placed between the points, and securely fixed by means of the apparatus in the box *h*. It will now revolve with the spindle of the lathe so as to ascertain the regularity, or what the workmen call the *truth*, of the motion, and to enable the turner to correct any irregularity; but before the tool can be applied the work must be trammelled to the nose of the spindle, by a contrivance called the dog and driver, the former being a sort of clutch, screwed upon the end of the work, and the latter a spur projecting form a chuck on the head of the spindle, and driving in its revolution the clutch and the work by a contact which will easily be understood by inspecting the subjoined cut, *fig.* 34., in which *a* is the chuck with its driver; and *c* the dog or clutch screwed upon the neck of a piece of work. The clutch is occasionally made differently so as to embrace the work, and when it is fastened upon any article which is very fine, or where injury might result from the direct operation of a screw, strips of sheet lead are interposed, to protect the surface.

Fig. 34.

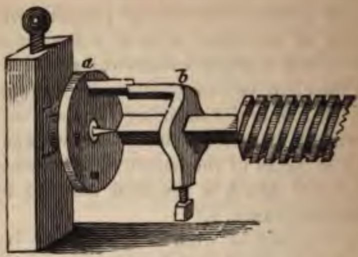


Fig. 35. is a chuck or disc of iron which may be screwed upon the spindle nose for the purpose of holding any work requiring to be turned across or at right angles with the spindle, or to be hollowed out inside; it has four projecting knobs on the margin through which screws pass, to enable the workmen to fasten the piece about to be turned, and also to adjust it to the proper centre. *Fig.* 36. is another chuck for the same purpose, but generally used for very large work; the concentric circles of perforations, and the four grooves extending across the plate, admit of the insertion of grip-knobs

Fig. 35.

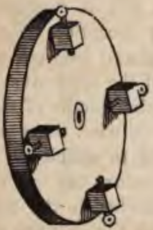
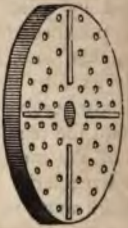


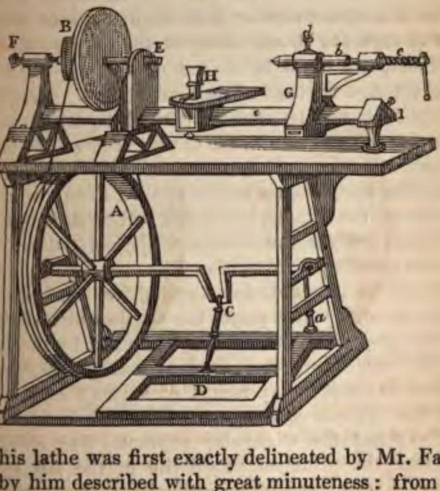
Fig. 36.



similar to those in the other chuck, so that the article to be turned may be held in any situation; especially when, as may often happen, the part to be rounded and the entire article may have different centres.

Several years ago, an elegant and useful lathe, especially for amateur turning, was manufactured by Mr. Maudslay of London. One of the most novel and attractive features in this improved turning machine was the substitution of a triangular or prismatic bar upon which the rest and centre puppet are constructed so as to slide, instead of sliding between parallel rectangular cheeks, as in the old-fashioned engines. The subjoined is the figure of the lathe manufactured by Mr. Maudslay.

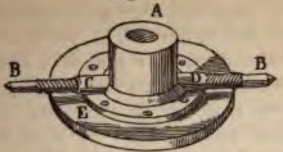
Fig. 37.



This lathe was first exactly delineated by Mr. Farey, and by him described with great minuteness: from that description the following particulars explanatory of the engraving are derived:—A (*fig.* 37.) is the power wheel with four grooves on the rim, in vertical lines with the four different diameters of the pulley B. This wheel is worked by a crank and connecting rod C, and a treadle D, in the usual way. The different diameters of the pulley and the grooves on the wheel are for the purpose of giving different degrees of velocity to the revolutions of the spindle E. These alterations are effected by transferring the catgut band from one groove to the other, and so on the pulley; a proper tightness of the band being obtained by means of the regulation screw, *a*, which with a similar screw at the other end elevates or depresses the crank axle in the degree required; the hooks in the end of the connecting rod C at the same time admitting of being screwed farther out or in, so as to adjust it to the effective working length. The spindle at E is screwed so as to receive a chuck, and a little beyond on the part that revolves between collars in the front puppet, it is made of a conical form, so as to prevent it from sliding forward: the other end is pointed, and works in the end of a screw F, which passes through the head of the hind puppet. From this description it will be obvious, that while, by advancing the last-mentioned screw, the conical neck will be driven forward, and the spindle be thus made to revolve steadily, so likewise that, when a tool is applied to any work on the nose of the spindle, the latter will be so far pushed back as to transfer the friction to the pointed end, and thus the spindle will revolve easily.

The centre puppet G has a cylindrical perforation at its top, through which passes the polished pointed rod *b*, which is moved by the screw *c*, and fixed by the screw *d*. The rest H is composed of four pieces, and is detained in its place by means of a small stiff screw. Both the rest and centre puppet are fitted so as to slide exactly along the triangular prismatic bar *e*, which constitutes the principal peculiarity of the lathe; and being each composed of several pieces they admit of being severally removed from the bar, without first taking off the standard I, and on this account the triangular bar is considered to be much superior to the double rectangular one in use with common lathes. Adapted to the screw E on the spindle nose is the universal chuck represented in *fig.* 38.

Fig. 38.

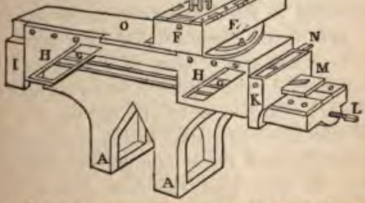


Near the bottom of the hollow screw, A, is another screw, B B, which is prevented from moving endwise by a collar in the middle of it. One end of this screw is cut *right-handed*, and the other *left-handed;* so that by turning it one way, the two nuts C D will recede from each other, or, by turning it the contrary way, they will advance towards each other. These two nuts pass through grooved openings in the plate E, and project beyond the same, carrying jaws like those of a vice, by means of which the substance to be turned is held.

For turning the faces of wheels, hollow work, &c., where great accuracy is required, Mr. Maudslay contrived and adapted to his lathe a curious apparatus, by him denominated a *slide tool.*

In this representation, A A (*fig.* 39.) form an opening

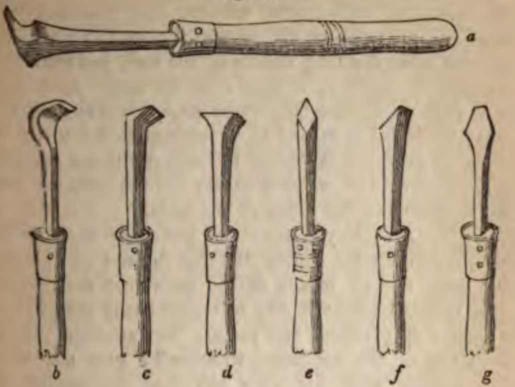
Fig. 39.



to receive the triangular bar already mentioned, which is closed against the lower surface of the bar by means of a clamp and screws (not represented), and in a similar manner to the rest and centre puppet. The tool for cutting, &c. is fixed in the two holders B B by their screws; these holders are fastened by a sliding plate C, which can be moved backward and forward by the screw D, causing the tool to advance or recede. When it is necessary, as the turning of the insides of cones, &c., that the tool should not be parallel to the spindle of the lathe, the screw at E, and another similar one behind, must be loosened so as to allow the circular plate under the box F to turn upon its centre. Near the four upper corners of the lower portion of the rest are small projections, two of which, G G, are seen: they have inclined sides, and fit into corresponding angular openings, H H, of the upper part of the instrument, which slides or rises between the piece I and the base K, in such a way as to prevent any other than a vertical motion. When this slide tool is placed on the bar to be used, the distance from the centre is adjusted by the screw L, which moves the slide M in its groove, and all the apparatus upon it; while by the screw N the slide may be moved in a direction perpendicular to the bar, and, the projections acting in the slits H H, the plate O will be raised or lowered as required.

The turning tools used by the whitesmith vary according to the purposes for which they may be wanted. The annexed figures (*fig.* 40.) represent those which are principally in use. These tools should be made of the very best cast steel carefully hardened, and tempered; they are inserted in wooden handles ten or twelve inches in length, and in the shape of that fully represented at *a*, which is what the artisan calls an eager tool, and is used for roughing the work; it has a rising and semicircular edge, so formed as to bite keenly, and the heel or spur is calculated to strike firmly into the rest, and thus prevent the tool from slipping or receding from the work. *b* is a bent double-edged tool, likewise used for roughing: it will, when dexterously handled, cut large shavings. *c d* are straight-edged tools, used in turning a level surface. *e* is what the workmen call a diamond tool; but it is in fact formed exactly like

Fig. 40.



a common graver, by cutting a square bar of steel obliquely in the direction of two of its angles; this is an exceedingly useful tool, and it is used accordingly in a great variety of ways, especially for turning shoulders. *f*, *g*, are different tools, used generally for purposes similar to those last mentioned.

In turning iron or steel, and indeed metals generally, and even wood, much depends upon the proper management of the tools. The best positions, however, in which the edge can be held for cutting, and the most advantageous elevation of the handle of the tool, can only be ascertained by experience. A person unaccustomed to turning would be likely so to apply the tools that they would either not cut at all or else they would bite so deeply as to spoil the work, if they were not jerked out of the operator's hand. To prevent these occurrences, the rest is generally placed at such a height that the contact of the tool with the work shall take place somewhat above a line drawn horizontally through the centre, the long handle of the tool being held against the arm, and its extremity elevated till the proper angle for cutting is obtained. This course, however, is very often reversed in turning very large articles, such as the outsides of cylinders, mill-shafts, cannon, &c., the tool being applied under the article, so that the workman not only presses upon the long handle of the tool, but sometimes actually sits upon it, to keep it to the cut. As all iron and steel work, especially when large, generates so much heat while being turned as to endanger the tool, it is usual to keep it wet during the operation, and generally a small stream of water is suffered to fall upon it, which much facilitates the effect of the tools.

With Maudslay's ingenious lathe, or even with a simply constructed engine like that figured on a preceding page, and by means of the tools just described, a vast variety of articles may be conveniently turned, with a degree of precision and success corresponding to the dexterity of the workman, whether he give motion to the spindle with his own left foot, or employ for heavier work a person to turn a large wheel, or even where, to give still greater effect to his operations, the prime mover is a horse, water, wind, or steam.

The degree of velocity with which the surface of an article, being turned, ought to pass the edge of the tool so as to be cut by it, differs materially in relation to different metals. Cast iron, in consequence of its open grain, and containing, as it generally does, many impurities, is required to revolve very slowly, so as to pass the edge of the cutting tool only at the rate of about one hundred feet per minute; wrought iron and steel are usually turned when revolving at a rate of about twice as quick; and brass cuts well when coming into contact with the chisels during a velocity of surface revolution equal to three hundred feet in a minute. To produce the requisite velocity according to the material or size of the work, pulleys of different diameters are fastened on the spindle, as already stated; so that the larger the work the larger the pulley, and *vice versâ*.

It must be obvious that a lathe, either on the plan of that described in page 138., or even of Maudslay's, can only be used with very partial exactness and despatch in the manufacture of straight mandrels, in which great accuracy is required, and hardly at all in the turning of those long iron rods used in the construction of steam-engines and various other descriptions of machinery, on account of the necessity of repeatedly shifting the rest, and the difficulty of keeping the work perfectly uniform in thickness through a considerable length. To facilitate the turning of cylindrical surfaces, and of long rods of whatever thickness, an ingenious contrivance, known as the slide lathe, has been invented, by means of which the greatest ease and exactness may be combined. The principle of this invention consists in so constructing and attaching the body or carriage of the rest, that, instead of being screwed down to one place during the operation of the tool, and requiring to be advanced at intervals as the work proceeds, it shall slide along the surface of the bench in a direction parallel to a line drawn through the centre of the spindle. At the same time the tool, instead of being merely held upon the rest with the fingers, is firmly fixed in its proper cutting position by screws, so that it can neither be driven off without taking effect, nor yet be drawn by its keenness so as to spoil the work. The whole is managed in such a way that, as the iron to be turned revolves between the centre points, the rest with its cutter or chisel advances slowly along in a certain direction, so as to produce a perfectly level rod. But, besides the exactness attainable by this method, there is likewise the advantage of economy; as one man who would with hard labour apply the tool to one point at once, at a common lathe, will easily tend and keep in work two or three slides.

There are various methods adopted for giving this sliding motion to the rest carriage, as by a rack, a screw, or a chain.

The cut, *fig.* 41., represents a perspective view, and *fig.* 42., the plan of an ingenious slide lathe for turning very long articles. The whole of the machine is made of iron, the length and breadth of the frame being regulated according to the size of the article to be turned. The two sides of the bed or frame, A A, are of cast iron, and placed in their supports B B, so as to be perfectly parallel throughout their whole length; they are finished with a sort of triangular edge, forming a smooth track for the centre-pin puppet C, and the slide rest D (*fig.* 42.). The principal spindle of the lathe E is an axle confined at its ends by brass bushes in the uprights of the frame F. Upon this axle are placed the two bevel spur wheels G H within, and the large cog wheel I without the uprights. At right angles with G H is placed a third bevel wheel M, the axle of which is in the frame K (see *fig.* 42.). This frame is constructed to slide a little by means of the lever rod L, so that the wheel M can be connected in a moment with either G or H, or be thrown entirely out of gear, so as to run clear between both, by moving the lever rod backward or forward with the prise at N. Over the pulley O passes

Fig. 41.

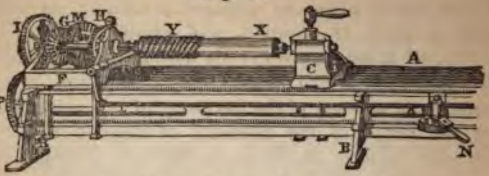
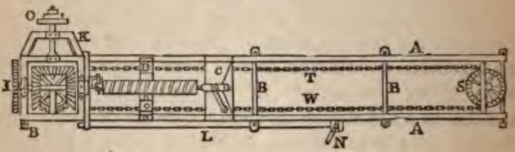


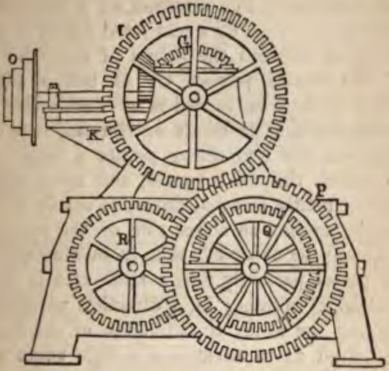
Fig. 42.



the strap connecting it with the prime mover. Such is the arrangement of the machinery as necessary merely to give revolution to the spindle and whatever work may be attached to it for the purpose of being turned: the mode of sliding the rest frame remains to be described.

Fig. 43. is an elevation of the end of the machine, the letters referring to which correspond to those indicating the same parts in he view and plan before given. I is the large cog wheel on the axle containing the two bevel spur wheels already described: this wheel connects with another of the same size, P, close behind which, and upon the same axle, is fastened the smaller wheel Q, connecting with its companion R. At each extremity of the frame, a wheel, S, is placed in a horizontal position, having on its upper periphery projecting points answering to and acting in the links of an endless chain T, W (*fig.* 42.). Only one of these wheels is shown, that at S (*fig.* 42.); the other is hidden by the head machinery: this last, however, is the wheel which gives motion to the chain, and is itself made to revolve by means of an endless screw on the axle of R (*fig.* 43.),

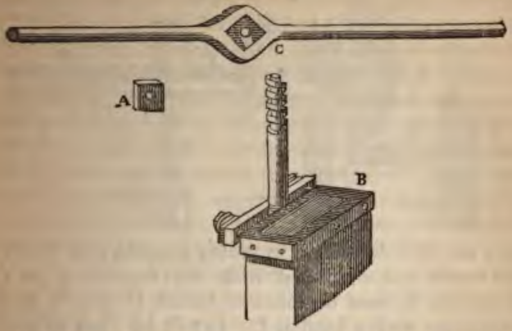
Fig. 43.



acting on a toothed concave rim of the said horizontal wheel. The chain is fastened on one side to a part of the rest-carriage D (*fig.* 42.), which descends and occupies the space between the sides of the frame: so that when the machine is put in motion, and the horizontal wheel at the head made to revolve, the chain operates upon the rest-frame, to which it is attached, and slides or draws it steadily along upon the superior parallel edges of the frame, like a wagon on a railroad, while the article to be turned by a tool fixed firmly in the rest, itself revolves between the points of the lathe spindle and of the centre puppet C, as before explained. When the work to be turned is of considerable length, and so slender that it bends or vibrates, it is usual to place between the two centre points a collar puppet, through which the work passes, and upon which the collars being gently screwed down, so steady it that the tool may be applied on either side of the support with effect. It may be observed, that, in turning the surface of large plates perfectly flat, a slide rest is used; but then, instead of moving in a direction parallel to the axis carrying the work, the direction of the rest-frame is so contrived as to advance at a right angle with the spindle.

Whitesmiths adopt various plans for the production of large screws, according to the nature of the article required, or as the measure of their means may enable them to obtain machinery more or less perfectly adapted to the purpose. In the making of screws for vices, for instance, workmen who have not a cutting engine use what they call a *burr*, or *burring* tool: in this case, the worm of the screw is produced by a process analogous to tapping. The burr A (*fig.* 44.) is a square piece of steel about four inches across, and an inch in thickness, having in the centre a hole screwed as accurately as possible with a square thread or worm. The vice-pin intended to be screwed, having been turned or filed to the exact size, is placed in the stock B, and held fast by means of a strong iron clamp screwed against it. The burr is then placed upon the point of the pin, and made to revolve slowly by means of the lever C, the arms of which are each three or four feet in length, and are driven by two men, who traverse a circle very slowly, and by a succession of gentle pushes, keeping the work well oiled. It is requisite in this process that no violence be used, otherwise the iron will be liable to be wrung asunder, and the labour be lost,—an accident that not unfrequently happens; and even when this is not the case, the screw-pin is sometimes infirm, in consequence of its having but partially resisted the torsion applied during an operation which, while it raised a considerable thread at the same time, elongates the iron pin one or two inches.

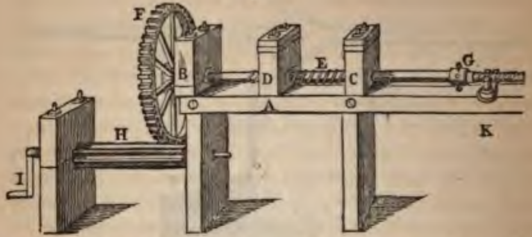
Fig. 44.



The subjoined is the representation of a very simple machine used for cutting vice-screws:—

A (*fig.* 45.) is a strong bench or gantry of wood, on which stand three chairs or puppets of cast iron firmly screwed down: those at the two extremities, B, C, are fitted with collars, caps, screws, &c. for the reception and regulation of an axis; the one in the middle, D, contains a brass bushtor box screwed inside. The axis E contains about the middle a screw twelve inches in length, and of the exact pitch or size of worm required to be cut: this screw passes through the box just mentioned; this axis likewise carries a cog-wheel F, and, at the opposite end, an iron chuck, with grip screws to hold the piece intended

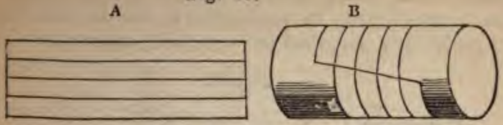
Fig. 45.



to be cut, G. Supported in proper puppets, underneath the bench and connected with the cog-wheel, is a pinion, H, thirteen or fourteen inches in length, and terminating with a handle, I. It will be plain to any person inspecting the cut, that, when by turning the handle the machinery is put in motion, the large cog-wheel will traverse the pinion to an extent greater or less according to the number of its revolutions, while the pin G will have a vermicular progress precisely corresponding to that of the regulator screw in the puppet D. This motion may be continued backward and forward to the necessary extent, until the pin be cut sufficiently deep by the application of a tool fixed in the rest K, and which, to prevent confusion, is not inserted in the cut.

Two capital objections exist against the foregoing machine in its application to any other purpose than that of cutting ordinary vice-pins: first, it does not conveniently admit of any alteration in the pitch or size of the thread or worm; and, secondly, it can only be conveniently used in cutting a screw within the length of the regulator and the pinion. Neither of these objections lie against the following method, which, however, is not often practised except by ingenious make-shift workmen. The screw-blank being exactly turned in the lathe to the thickness and length required, a piece of writing-paper, A, is ruled with parallel lines,

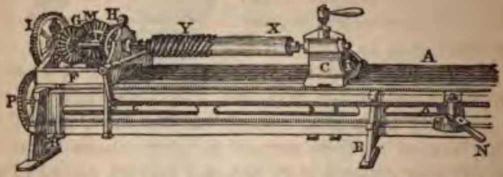
Fig. 46.



corresponding in their distances with the pitch or size of worm sought to be produced. The paper is then clipped, until, when wrapped round the mandrel to be cut, the ends shall meet; but the lines, instead of being united at their respective terminations so as to form merely concentric circles, are carried round in an oblique direction, so as to have advanced the outer, and consequently every other line, the entire space of a single interval at the line of contact, as in B (*fig.* 46.). The lines will thus wind heliacally round the outside of the mandrel, so as to form the outline of the intended screw. The ruled paper being in this manner pasted upon the mandrel, and suffered to fasten by becoming dry, the copy is transferred to the iron by cutting it in the screw-line with a hammer and chisel. On removing the paper, the iron will be found to be channelled sufficiently deep to serve in giving direction to any tool that may be applied to cut out the worm to a proper depth, care being taken to proceed gently and with caution, until the cutting have so far proceeded as to be deep enough to carry along the tool with ease and safety. The top of the rest for this operation must be perfectly smooth and level. It will be obvious, that by this process a given portion being prepared or finished at a time, a screw of any length may be produced. Besides, however, the tediousness of the operation, there is a want of accuracy in the result, considerable or otherwise, in proportion to the dexterity of the workman, and the occurrence of accidents; so that, at the best, in this case, as well as with the burr, an irregular, or what the workmen significantly term *a drunken screw*, is most likely to be produced.

The most perfect engines for the purpose of cutting

Fig. 47.



large screws are the lathes with a sliding rest; and perhaps the principle of their operation may be rendered most conspicuous by a reference to the ingenious machine already described in page 143*, and the model of which was kindly lent to the writer by Messrs. Gallimore, of Sheffield, who have been noted for their manufacture of large screws, especially those used for elevating the breeches of cannon during the late war; and before government began the manufacture of screws, &c. at Woolwich. In cutting large screws by means of the slide lathe, the operation and principle are exactly the same as those already described relative to the turning of mandrels by the same machinery; the application of the tool in all slide turning being essentially to produce a screw upon the work. The mechanical difference of the effect depends altogether upon the relation which the horizontal motion of the cutting tool bears to the velocity of the revolving body upon which it acts. If the work make a revolution before the edge of the tool has advanced through a space more than equal to its own breadth, the effect will be that of turning, or uniform smoothness, as exhibited by the roller at X (*fig.* 47.), every portion of the surface being cleared away to a given depth, so that, were the shaving to come away entire, it would be a fillet of sufficient length to wrap the mandrel, from which it was cut, all over from end to end. On the other hand, if the work make less than a revolution before the edge of the tool has moved through a distance equal to its own breadth, the result will be a screw, as Y (*fig.* 47.), the pitch or speed of which will be in the ratio of the progress of the cutter, as compared with the revolution of the work; and the shaving a riband, which will only wrap the mandrel throughout its length by allowing intervals corresponding to the size of the worm, or that part of the mandrel which has not been lowered by the tool.

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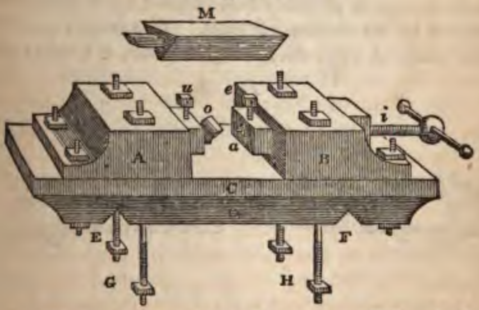
* For convenience of reference in the subsequent description, the cut representing a perspective view of this machine is repeated.

The relation between the progress of the cutter and the revolution of the work, and consequently the pitch of the screw, is varied by changing the wheels I, P (*fig.* 47.); every increase of the size of the former and reduction of the latter giving a quicker pitch to the screw, and *vice versâ.* When the pitch of the screw is very considerable, as is required in the fly press, the worm, instead of being left with the whole breadth of its surface entire, is generally cut again and again, so as, in fact, to produce three or four worms, though the pitch of the screw is the same as if there were but one. The cutter and its sliding frame, which, for the sake of perspicuity, are not shown in the perspective view of the machine referred to, will be clearly understood from the annexed figure. A, B (*fig.* 48.), are two cast-iron bearers, fitted to the cast-iron bed-piece C D, which is made to slide on the edges of the lathe-frame by means of the hollows E, F, and being kept steady by the

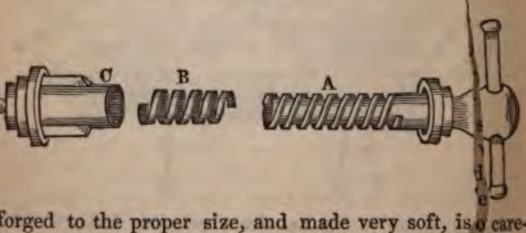
Fig. 48



screws G, H, over which a piece of wood or metal is put, so as to slide underneath the bench or frame. *a* is the cutter or turning tool, made of the best cast steel, and formed by filing upon the end of a steel prism, of which M is an enlarged figure: this cutter passes through a triangular aperture in the boss B. It is kept steady when at work by the screw *e*, and pushed forwards so as to bite more keenly, or, after every course of cutting or turning, by means of another screw, *i*. In the opposite bearer is a piece of iron, *o*, with a bent or hooked projection, adapted to pass over, and keep to the action of the cutting tool, whatever article is cut or screwed, and which, but for some such contrivance, would be liable to rise or jar, especially if slender or of considerable length. This piece is detained in its place by the screw *u*. The other screws, of which there are eight, are for the convenience of moving the bearers backward or forward by means of grooves in the bed plate C, according to the circumference of the body which is required to revolve between the cutter *a* and the steadying claw *o*.

The boxes, or insides, in which all the before-mentioned screws work, are next to be described; they are manufactured by three very different methods. The most ancient is probably that adopted by whitesmiths in general in the making of vices. The course is this:— The screw A (*fig.* 49.) being finished, a band of iron,

Fig. 49.



forged to the proper size, and made very soft, is carefully wrapped round in the hollow of the screw, so as to form an exact counterpart to the worm; this coil, B, in being taken from the mandrel screw, is filed bright on the outside, and inserted within the welded iron tube C, which is likewise cleaned inside. The worm being found, on trial by the screw, to be properly adjusted, the whole of the worm and interior of the box are plentifully covered with a mixture of pounded borax and water, and upon this is thrown a sufficient quantity of bits of brass wire to unite by their fusion the worm and box. The whole is then enveloped in a thick mass of fire-clay, and submitted to the fire; the workmen urging the heat with the bellows until the lump appears red-hot: the melting of the brass, and consequent soldering of the work, is indicated by a dense blue flame, which arises from the hearth, and which, after having continued for a few minutes, serves to assure the workman that the fusion is complete. The article is then withdrawn from the fire, and rolled until it cool, upon the ground, in order that the molten brass may not fall in gluts on one side, and so impede the progress of the screw. The clay is then knocked off, the screw worked into the box with oil, and the whole finished by filing or turning on the outside.

The next method, which is generally that resorted to in the production of boxes for fly-screws and others having several worms, consists in casting the work in brass upon the mandrel, which in this case becomes a model. To do this, it is merely necessary to place upon the iron screw a wooden or clay model of the size of the intended screw-box, and then mould the whole in a case of proper sand. The screw is then taken out, and the model removed; after which the screw, having been covered with a mixture of whiting and water, of the consistence of paint, to prevent the brass from adhering to the iron, is returned to the moulding case, and the brass poured in, so as to surround the screw at the place and to the extent occupied by the model. On becoming quite cool, the work is placed upon the anvil, and the brass lump hammered all round until sufficiently loosened by expansion to allow the screw to be withdrawn, which it will do readily when the latter is quite smooth and cut very true: any trifling irregularities are corrected by working the screw a few times through the box.

The foregoing, it will be supposed, is a method which could hardly be applied with success in the case of very large screws, where the box, from its size, would be inconvenient to loosen by hammering, and the friction of the parts in contact so very considerable. Boxes are, therefore, now generally cut by the manufacturers inside, by the same machinery which has been described for the cutting of mandrel screws. To refer once more to *fig.* 47., it will be easily understood, that if, instead of the screw revolving between the centre points, we substitute a mandrel with a point or cutter projecting from its surface; and if we place a brass box in the sliding rest-carriage, by means of clutches, or any other contrivance, so that the mandrel shall work through it; then, by giving the regular motion to the lathe, the box may be both turned and screwed in the inside with the same ease, and to exactly the same pitch, as any mandrel screw which it may be required to fit.

Considerable improvements have been from time to time proposed, and many of them adopted, in the manufacture of screws, particularly within the last few years, during which period the increased demands upon the labours of the engineers and mechanist, have been the means of producing greater facilities of production and for repairs.

It has long been felt as a great inconvenience, that there was no uniformity of system by which the sizes of screws were regulated. To effect this more perfectly than has hitherto been done, Mr. Whitworth, of Manchester, has introduced a measuring machine and a set of apparatus, by the employment of which the utmost amount of accuracy can be insured. By it the sizes and arrangement of screw threads is rendered easily practical amongst engineers in general. It can be readily understood how important this is, when we consider the result of an accident to machinery at any distance from the place of manufacture, where even the tools for cutting particular threads on screws have themselves to be manufactured. Mr. Whitworth's system has been fully described in a paper communicated, in 1841, to the Institution of Civil Engineers; and since the Great Exhibition it has excited much attention at home and abroad. Mr. Whitworth there exhibited different sizes of guide stocks, and the several dies, taps, &c., for producing the corresponding screws, which he calls the standard forms of his system; and, also, sets of standard gauges, by the use of which corresponding parts of machines may be prepared separately, with sufficient accuracy to fit without trial.

This appears to be an appropriate place to introduce some notice of the rivetting machine. The invention of the rivetting machine originated in a turn-out of the boiler-makers in the employ of Mr. Fairbairn of Manchester. On that occasion the attempt was made to rivet two plates together by compressing the red-hot rivets in the ordinary punching press. The success of this experiment immediately led to the construction of a rivetting machine, in which the moveable die was forced upon the rivet by a powerful lever acted upon by a cam. A large stem is made of malleable iron, having an iron strap screwed round the base; it renders the whole perfectly safe in the case of the dies coming in contact with a cold rivet or any other hard substance during the process. Its construction allows the workman to rivet angle-irons along the edges, and to finish the corners of boilers, tanks, and cisterns. The stem or pillar being between four and five feet high, the machine is of very extensive application, as it allows of its rivetting the fire-box of a locomotive boiler or any other work within a given depth. In addition to these parts, it has a broad moving slide, in which are three dies corresponding with others in the wrought-iron stem. By using the centre die every description of flat and circular work can be rivetted; and by selecting those on the sides it will rivet the corners, and thus complete vessels of almost every shape. The machine being made in a portable form, it can be moved on rails, and thus brought to suit any article suspended from the shears. By the introduction of a knee joint the dies have a variable motion given to them, and the greatest force is exerted at the proper time, viz. the closing of the joint and the finishing the head of the rivet.

This machine fixes in the firmest manner, and completes, eight rivets of three quarters inch diameter in a minute, with the attendance of two men and two boys to the plates and rivets; whereas the average work that can be done by two rivetters with one "holder on" and a boy, is 40 three quarter inch rivets per hour; the quantity done in the two cases being in the proportion of 40 to 480, or as 1 to 12, exclusive of the saving of one man's labour. The cylinder of an ordinary locomotive engine boiler, 8 feet 6 inches long and 3 feet diameter, can be rivetted and the plates fitted completely by the machine in four hours; whilst to execute the same work by hand would require, with an extra man, twenty-four hours. The work produced by the machine is likewise of a superior kind to that made in the ordinary manner, the rivets being found stronger and the boilers more free from leakage and more perfect in every respect. The rivetting is done without noise, and thus is almost entirely removed the constant deafening clamour of the boiler-maker's hammer.

It may not be inappropriate to introduce into this article on whitesmith's work, a passage or two on the subject of cutting iron and steel by methods not commonly known or practised. In the French *Annales de Chimie*, M. Duffond, director of the iron-works at Montalaire, near Creil, in a letter to M. d'Arcet, describes a "method of sawing cast-iron." The writer of this communication describes his experiments as having been attended with complete success. The following extract is from the translation of this letter, given in the Repertory of Arts, vol. xxii.:—"My first trial was made with the support of a grate, 108 millimètres, (4·25 inches) thick. This piece of cast-iron was heated in a forge fire with coal; and as soon as it had acquired a sufficient degree of incandescence, it was placed on an anvil, and I sawed it with a common carpenter's saw, without any difficulty, and without any injury to the saw, which I dipped immediately into cold water. The carpenter continued to work with the same saw without having any occasion to repair it.

"In this, my first trial, a little accident occurred. The end of the iron I was sawing off not being supported, it broke when 20 or 25 m. (about a line), remained to be cut through: but this slight defect I immediately removed with the saw. Convinced of the ease with which the common saw would cut hot cast iron, I afterwards applied it to the demands of ironworks.

"I had occasion to shorten a pivot of 135 m. (5·3 inches) in diameter; but afraid of breaking it if I cut it cold, — an operation besides very tedious and uncertain, unless executed in a lathe, — I had resolved to cast another, when the experiment just mentioned determined me to saw it.

"Having marked the place of section with red lead, I placed the pivot in a reverbatory furnace; and when I thought it sufficiently hot, I had it taken out of the furnace and placed on an iron support, so that the two ends had equal bearings. In four minutes, with two saws, which I used and cooled alternately, the piece was cut off; to the great astonishment of my workmen, who found the saws unhurt.

"The same day I performed a still more difficult operation. I had an anvil, which I was about to cast afresh, because it was 41 m. (1·6 inch) too thick, so that it could not be placed in its bed.

"I marked the place of the saw-kerf with red lead. The two cuts to be made were 217 m. (8·5 inches) long, by 189 m. (7·4 inches) high; and the thinness of the piece to be cut off required precision. This anvil was heated in a reverbatory furnace, in the same manner as the pivot; and when sufficiently hot, two workmen took hold of it with a strong pair of tongs, and laid it on a block of cast iron. It was cut with much ease and precision, by the same saws that had been used in the preceding instance. In the course of these experiments I remarked,—

"1. That hot cast iron may be sawed as easily, and in the same space of time, as dry wood.

"2. That to diminish the resistance, the saw should be set fine.

"3. That iron heated in a furnace saws more easily than if heated in a forge: and the reason is simple; — in a furnace it is heated equally throughout; while in a forge the part near the tewel is almost in a state of fusion, while that opposite to it is scarcely red-hot.

"4. That the iron must not be made too hot; for, if its surface be too near a state of fusion, the saw will be clogged, and the process will not go on well.

"5. That the saw should be moved very quickly; because then it will be less heated, make its way better, and the cut will be more clean and exact.

"6. Lastly, that the iron should be so placed as to have a firm bearing everywhere, except where the saw is to pass, otherwise it is liable to break before the cutting is finished."

M. d'Arcet, in a note, among other observations, says, that "M. Molard used a common saw, and succeeded perfectly in cutting various pieces of cast iron, without injuring its teeth. He observed that the iron should be heated only to a cherry red; and that it should be cut briskly, using the whole length of the saw. M. Molard found that this process was known to a workman of M. Voyenne, who practised it in fitting the cast iron plates used in making stoves.

"It is probable that this simple operation may be known in other workshops; but it is lost, as it were, since eminent persons in the arts are generally ignorant of it."

That cast or wrought iron may be sawn when at a red heat, need not be doubted by those who are aware how easily and commonly it is filed at a similar temperature. Nobody, however, who knows any thing about such matters will be credulous enough to suppose that hot cast iron may be sawn "as easily, and in the same space of time, as dry wood;" and still less, that after such an operation the saw would be found "unhurt." The practice of stove-grate makers is opposed to this principle: for instead of reducing large plates by sawing, either hot or cold, they generally break them on the edge of the anvil, in a manner similar to that by which a mason sizes the slates which he is about to use, — the fractured edge being afterwards levelled on the grindstone.

Another experiment in cutting steel is still more curious. Mr. Barnes, of Cornwall, in America, having occasion to repair a cross-cut saw, recollected having heard that the religious sect called Shakers sometimes made use of what is called a buzz to cut iron. He therefore made a circular plate of soft sheet iron, fixed an axis to it, and put it in his lathe, which gave it a very rapid rotatory motion. He then applied to it, when in motion, a common file, to make it perfectly round and smooth, but *the file was cut in two by it*, while it received itself no impression. He then applied a piece of smoky quartz, which produced the desired effect. He then brought under it the saw-plate, which in a few minutes was neatly and completely cut through longitudinally. When he stopped the buzz he found it had not been worn by the operation, and that he could immediately apply his finger to it without perceiving much heat. During the operation there appeared a band of intense fire around the buzz, which continually emitted sparks of fire with great violence. He afterwards marked the saw for the teeth, and in a short time cut them out by the same means. The foregoing narrative of what had been done in America having appeared in Silliman's Journal, Mr. Perkins met with it, and tried the experiment with success in London. The writer of this paragraph too, willing to satisfy himself by ocular demonstration of so curious a fact, attached to the spindle of a common lathe a disc of soft sheet iron, not thicker than that of which tin utensils are commonly made, and only about three inches in diameter: on applying the sharp edge of a hardened steel chisel, the iron was cut by it; but on causing the disc to revolve very rapidly, it presently overcame the tool, evidently by tempering it at the point of contact: when the cutting had once commenced, it was easily continued until a deep slit was produced in the steel. The theory of this phenomenon has been considered of difficult solution — some persons even referring it to magnetism. To the present writer it appears to be simply an effect of attrition, upon the principle of which we frequently see a soft body wear away a harder, when the impetus of motion is given almost entirely to the former. A familiar illustration may often be witnessed in the works of an old clock, — the click, although of steel or case-hardened iron, will often be worn completely through by its operation on the teeth of the ratchet wheel, the latter being merely made of brass, and hardly worn at all. It was clear, however, in the experiment alluded to, that no operation of the iron upon the steel took place until the latter had become softened by the friction of the disc, as an intense bluing accompanied the line of section. It appears that cast iron does not, in the same manner, yield to the action of soft iron. An iron-worker, in a communication to the editor of the New York Journal above named, says, — "Having occasion, a short time since, to cut a plate of cast iron three eighths of an inch thick, it was thought that the plan recommended for cutting steel by iron might succeed in this case. Accordingly a disc of sheet iron was placed on an axis, and adapted to a water lathe in such a manner as to revolve with great rapidity. This disc would cut hardened or soft steel, or wrought iron, with much facility, but produced not the slightest effect on the cast iron. I confess I am quite at a loss to explain this difference in the action of the disc."

CHAP. VII.

STOVES AND FIRE-GRATES.

EARLIEST DOMESTIC FIRE-PLACES. — CHIMNEYS. — DOGS OR ANDIRONS FOR BURNING WOOD FUEL.—OLD FASHIONED GRATES FOR COAL. — AMERICAN FIRE-RANGES. — MODERN STOVES. — TREDGOLD'S OBSERVATIONS ON THE FORM AND SIZE OF FIRE-PLACES. — REGISTER AND HALF REGISTER STOVES. — FOREIGN CLOSE STOVES.— RUSSIAN AND CHINESE STOVES. —PYRAMIDAL STOVES. — COCKLE FOR HEATING WITH HOT AIR.— STEAM AND HOT WATER. — METHOD OF CASTING STOVES. — DIFFERENT STYLES OF FINISHING. — PRODUCING NEW PATTERNS. — CANADIAN, FRANCINIAN, AND SMOKE-CONSUMING STOVES. — OVENS AND BOILERS. — COOKING APPARATUS. — FENDERS, PIERCED, EMBOSSED, WIRED, AND CAST. — FIRE-GUARDS. — ASH-RECEIVERS. — FIRE-IRONS.

THE word *stove*, as used in the title of this article, is not intended to be taken in its strict acceptation, as signifying a close and generally detached receptacle for a fire, but in the loose sense of the trade, as implying almost any description of manufactured fire-place beyond a mere grate. Of the manner in which the ancients warmed their habitations few and but indistinct traces remain. The very earliest buildings, of which the ruins or accurate descriptions have come down to our times, certainly exhibit no traces of chimneys; and hence it has been imagined that the occupants must have lighted a fire in the middle of a room, the roof of which was formed with an opening for the escape of the smoke, as, indeed, is the case in some countries at this day. The first remove from this unpleasant and inartificial arrangement seems to have been the adoption of the portable brazier, or fire-pan, which might be used in any apartment requiring to be warmed. This mode of diffusing artificial heat became very general in most of the cities of southern Europe, where it still continues common. The fuel, of course, is chiefly charcoal, or at least wood; and it can be no wonder, considering the pernicious effluvia which must be emitted, and the occasional closeness of the rooms, that instances of suffocation should be far from uncommon: indeed, in England, hardly a winter elapses without the newspapers containing accounts of fatal accidents occasioned by the incautious introduction of a chafing-dish of coals into ill-ventilated sleeping-rooms.

It appears that, in Seneca's time, the better sort of people began to construct tubes in the walls to convey the heat into the upper apartments, the fire-places being still placed below: as not only the heat, but likewise the smoke, would ascend these vents, they suggested the idea not only of flues, but even of stoves themselves, the situations and proportions of which successively underwent an infinity of changes, according to the localities, the wants of the inhabitants, or the style of the decorations.

A history of the various contrivances for producing artificial warmth in this country might be considered, to a certain extent, a record of the progress of domestic comfort, or, as some might contend, of the national effeminacy through successive periods. Nothing is more certain, than that the temperature of our habitable apartments generally is maintained and considered comfortable, if not healthful, at an elevation unknown to our forefathers in their sitting-rooms. In the affair of cooking, the contrast between former and modern times seems to be less striking. Certainly, if we may believe various published descriptions of the baking, and roasting, and boiling operations daily carried on in the ancient baronial kitchen,—and the massive ranges still extant in some places seem to corroborate such descriptions,—the temperature of a first-rate cookery establishment, in days of yore, must have been pretty high. This state of things, however, belongs to a period hardly earlier than the fourteenth century. Before that era, except for culinary and smithery purposes, our robust forefathers appear to have cared but little about the introduction of artificial heat into their dwellings, and not to have cared at all about it during the warmer months of the variable year of our variable climate. Even so late as the reign of Henry VIII., it seems no fire was allowed in the university of Oxford, if we may believe the writers who assert that the students, after supping at eight o'clock, went to their books till nine in winter, and then took a run for half an hour to warm themselves previously to going to bed.

In the year 1200, chimneys were scarcely known in England: one only was allowed in a religious house, one in a manor house, and one in the great hall of a castle or a lord's house; but in other houses they had only the *rere dosse,* a sort of raised hearth, where the inmates dressed their food and dined, and from which the smoke found its way out as it best could. The origin of chimneys has, indeed, been referred to the Venetians and the middle of the fourteenth century; but they are certainly of greater antiquity in England, as is clear from the testimony of our countryman Robert Langland, who, in his "Vision of Pierce Plowman," written in "the tyme of Kynge Edwarde the Thyrde," makes particular mention of a "chamber with a chimney." To the same purport might likewise be cited Mr. King's learned treatise on ancient castles, and the engravings in *Vetusta Monumenta.* The testimony of Harrison, in his description of Britain prefixed to Holinshed's Chronicle, although often quoted, is too curious to be omitted on this subject. Writing in the reign of Elizabeth, he says,—"There are old men, dwelling in the village where I remayne, who have noted three things to be marvelously altered in Englande within their sound remembrance. One is, the multitude of chimnies lately erected; whereas, in their younger dayes, there were not above two or three, if so many, in most uplandish towns of the realm (the religious houses, and manor places of the lords, always excepted, and peradventure some great personages); but each made his fire against a *rere dosse* in the hall, where he dined and dressed his meat."

Fossil coal is generally supposed to have been discovered near Newcastle in 1234, and to have been used in London about 1400. Considerably later than this the House of Commons interdicted the use of coal in

London during the sitting of parliament. In what particular manner, or to what extent, it might be burned at the latter period, is not very clear: wood billets, however, long remained the principal fuel of the south; and the apparatus for burning such fuel with economy and effect may be regarded as the most ancient deviation in metal from the rude simplicity of the *rere-dosse* towards the close fire grate, and the endless and elegant varieties of the modern stove. The allusion here intended is to those useful iron tressels called hand-irons, or andirons, formerly so common in this country, and yet occasionally to be met with in old mansions, under the appellation of dogs.

When in use, the irons were placed beside each other, at such a distance as might be required from the length of the brands intended to be burnt.

Before the introduction of close fire-places, these articles were found not only in the houses of the better sort of people, but in the bedchamber of the king himself. Strutt, writing in 1775, says, "These *awnd-irons* are used at this day, and are called *cob-irons:* they stand on the hearth, where they burn wood, to lay it upon, their fronts are usually carved, with a round knob at the top: some of them are kept polished and bright: anciently many of them were embellished with a variety of ornaments." In another place, after giving an inventory of the furniture of the bedchamber of Henry VIII., in the palace at Hampton Court, including "awndirons, with fire-fork, tongs, and fire-pan," &c. Strutt adds, "But, lest our ideas should be sunk too low, it may be necessary here to remark, that the *turned chairs*, the *joyned stools*, the *awnd-irons*, &c. which we find mentioned in the above inventory are, it is true, such sorts of furniture as at this day can only be seen in the houses of the poorest and meanest people; but at that time they were often made extremely grand, enriched with carved work and gilding, insomuch that they composed part of the furniture, not only in the houses of the chief nobility of the realm, but also in the palace of the king himself; and of the *awndirons*, or, as they are called by the moderns, *cob-irons*, myself have seen a pair which, in former times, belonged to some noble family. They were of copper, highly gilt, with beautiful flowers, enamelled in various colours, disposed with great art and elegance." Shakspeare, with graphic exactness, describes a pair belonging to a lady's chamber, in his play of "Cymbeline." Iachimo, by way of giving proof to Posthumus of a stolen interview with his innocent wife Imogen, says,

> —— "The roof o' the chamber
> With golden cherubins is fretted: her *andirons*
> (I had forgot them) were two winking Cupids
> Of silver, each on one foot standing, nicely
> Depending on their brands."

Besides the andirons, properly so called, and what were denominated *creepers*, a smaller sort, with short necks, or none at all, and usually placed between the former, to keep the ends of the wood and the brands from the floor, that the fire might burn more freely, has been mentioned a middle sort of irons, thus pleasantly described by a writer in one of the earlier volumes of the "Gentleman's Magazine:"—"Now, there being in a large house a variety of rooms, of various sizes and for various purposes, the sizes and forms of the andirons may reasonably have been supposed to have been various too. In the kitchen, where large fires are made, and large pieces of wood laid on, the andirons, in consequence, are proportionately large and strong, and usually plain, or with very little ornament. In the great hall, that ancient seat of hospitality, where the tenant and the neighbours were entertained, and, at Christmas, cheerfully regaled with good plum porridge, mince pies, and stout October, which happy custom some of the very oldest men now living may possibly remember, the andirons were commonly larger and stronger, able to sustain the weight of the roaring Christmas fire; but these were more ornamented, and, like knights with their esquires, attended by a pair of younger brothers far superior to, and therefore not to be degraded by, the humble style of *creepers:* indeed, they were often seen to carry their heads at least half as high as their proud elders. A pair of such I have in my hall; they are of cast iron, at least two feet and a half high, with round faces, and much ornamented at the bottom."

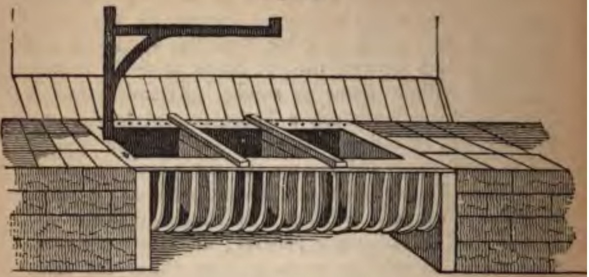
As an article of manufacture, andirons are little known in England; a few are made at Birmingham for exportation; in the United States they constitute a considerable item in traffic with the various parts of America, where wood is the only fuel of the inhabitants.

As the taste for luxuries was cultivated, the enterprise of the whitesmith increased, and, the consumption of pit-coal becoming general, the transition from andirons to fire-places composed of connected bars was obvious and easy; the new contrivance, for a time, exhibiting more or less traces of its origin. In rural districts, where the village blacksmith was the only artificer in iron, proofs of this fact are frequently apparent, in the massive grates, the bars of which are rivetted into stout iron standards, rising at each end to a considerable height above the fire, and terminating in large knobs of the same metal, the brightness of which harmonises with the general neatness. In the houses of the nobility the grates were, of course, of a more expensive and ornamental description, still retaining, however, as their most conspicuous feature, two ornamental pillars, or standards, in front, similar to those which exhibited the taste or ingenuity of the manufacturer in the ancient andirons. Besides these supports, the back plate, cast from a model of carved work, was added, and, generally, under the lowest bar, a filigree ornament of bright metal, which, under the designation of a fret, still retains its place in many modern stoves. Movable fire-places of this description may be met with about 200 years old. America, whose immense forests have hitherto been regarded as inexhaustible, and where, in consequence, andirons, or dogs, have been most largely in demand, has latterly manufactured metallic stoves and ornamental fire-places to a large extent.

For, as we have just intimated, notwithstanding the vast quantity of wood produced and consumed for fuel, the increasing price of that sort of firing, if not the indications of its exhaustibility, has rendered the discovery of anthracite, or stone coal, a matter of very great importance to the states where the increase of population is most rapid. Even in New York this species of fuel is getting into general use; it burns with an intense heat, but without flame or smoke. According to late accounts, there is scarcely a house erected in the city which is not furnished with grates for its consumption; and in very many old houses the fire-places for wood and grates for Liverpool coal have given place to those in which anthracite is burnt. In Philadelphia the use of this fuel is still more general; and the saving, in some cases, is said to be more than thirty per cent. upon the former expenditure in the maintenance of wood fires. The alteration required in the construction of the fire-places in which wood or English coal had been previously used, has led to a corresponding attention on the part of the American stove-grate makers; and hence the United States journals abound with advertisements, and contain numerous cuts, of ranges calculated, in general, to burn either wood or coal, according to circumstances. Of these the front bars are frequently vertical and curved underneath, so as to form the bottom or basket: when for cooking, the fire-place is made to admit of being contracted or enlarged, by means of movable cross-plates, as in the representation on the opposite page (*fig.* 50.); a plan very early adopted in the old English kitchen ranges.

It is, however, properly speaking, within the last century that we must look for the commencement of that vast and profitable trade which is now carried on in the article of stove-grates and hot-air or close stoves of every description in this country; an article in the superb and diversified manufacture of which the bright-iron worker's art furnishes no parallel. In the construction of fire-places formerly, when economy in fuel, where a fire was required, was as little thought about as was the maintenance of a uniform temperature in the apartment, it was generally thought sufficient for

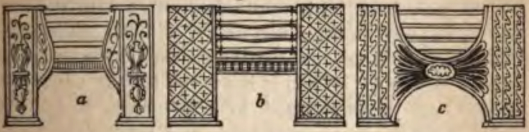
Fig. 50.



the purpose, that the receptacle for the coals or the billets should be ample, and that the smoke should ascend the proper vent. The former desideratum it was easy enough to attain; but complaints of smoky chimneys have been common from the days of Pierce Plowman (Edward III.) to the present hour. It is to a better knowledge of the theory of heat, in its practical application for domestic purposes, as developed by count Rumford, in his Essays, that we are indebted for that attention to the form and fixing of stoves which has led to the present perfection of the article. Instead of the old-fashioned yawning chimneys, which were thought necessary to receive and carry off the smoke, and which also carried away the heat in a degree proportioned to the size of the lower orifice, it was shown that, by contracting the fire-place upon such a principle as to regulate the draught so as just to carry away the smoke, the heat might be reflected into the apartment with an effect and an economy in the consumption of fuel not previously thought of. Attention once aroused to the subject, the advantages of contracted fire-places, both for use and ornament, were universally acknowledged; and the builders and furnishing ironmongers of the metropolis, finding it to be their interest to concur in the general conviction, became the early and spirited patrons of that manufacture which we are now considering.

From about the year 1780 to 1800, the London and country markets were mainly supplied by a diversity known to the trade as Bath, Pantheon, and Forest stoves; the black castings for which were supplied largely from Scotland, as well as from various places in England, where, in some instances, the recent manufactures have been brought to such an amazing degree of perfection. The three stoves above named, and which were in such large demand a generation ago, differed from each other but little, except in the form and decorations of their front plates; which, with the bars, whether bowed or straight, commonly consisted, when the article was light, of a single casting. The three fronts are represented below (*fig.* 51.): — *a*, the Bath stove; *b*, the Pantheon stove; *c*, the Forest stove.

Fig. 51.

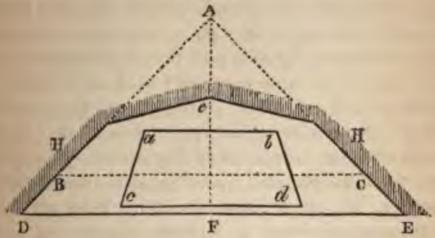


The latest improvement, however, founded upon the regulation of the draught, and the radiation of the heat, as well as combining in general the most superb manufacture, has been what is denominated, from its principle, the Register stove. This stove is made so as to occupy the entire space within the chimney jambs; it is perfectly close and entire, having the back, sides, roof, and front composed of metal plates. The front, of course, is intended to fit exactly into the opening between the apartment and the flue; the sides are coved or inclined backward, so as to reflect the heat of the fire; and the roof is furnished with a falling door, or register, to afford egress to the smoke, and capable of being raised or lowered, so as to regulate the draught by means of a click or ratchet: when there is no fire in the grate this click is pushed away, and the door falling, closes the stove completely against the falling of soot or the circulation of air. Iron being a rapid conductor of heat, the effect of any fire would be greatly augmented by constructing its receptacle of fire-bricks, or some other slow-conducting material; but such contrivance is rarely either practicable or necessary, in the elegant article of register stoves constructed on a good principle.

A great variety of methods have been from time to time introduced, for the purpose of obtaining, in ordinary stoves, the largest amount of heat from the combustion of the smallest quantity of fuel. Amongst those which have been the most successful may be named *Keene's registered conducting leaf stove.* The difficulty experienced in heating some large rooms in the depth of winter, led to the construction of the grate. The conducting leaf stove is formed of plates of metal so placed that each one is a conducting leaf, a portion of which goes down, as it were into contact with the fire, and is exposed to the direct action of heat. The heat thus received is rapidly distributed over the whole surface of the leaf. When it is desired to take advantage of the heat communicated by conduction, it is only needful to set the valves open, and permit the air to circulate around the leaves; by closing the valves the circulation is suppressed or modified at pleasure. The rapidity of the conduction, and process of correction, prevents the metal from attaining too high a temperature. In an apartment almost insensible to the action of the ordinary fire-place, and in which the thermometer indicated but a feeble tendency to rise two hours after lighting the fire, it was effected to the extent of 20° in a little more than as many minutes after lighting a fire in the leaf stove.

The following observations and diagram, from Tredgold's valuable work on warming, and ventilating buildings, will show more clearly the principle of the register stove. "It has been shown that we should have only a small quantity of metal in contact with the fuel; but there is no objection to employing metallic surfaces, so that they may act as reflectors of heat; only they should not be any where in contact with the bars, or other metal round the fire. The covings, or sides, of a fire-place, H H (*fig.* 52.), are now commonly placed in an oblique position, according to the plan proposed by count Rumford, whose object, in giving them such a position, was to reflect the heat into the room. But to gain any advantage by reflection, the matter of which they are formed should be capable of reflecting the chief part of the heat which they receive; instead of which, we most frequently find a blackened surface. Bright or polished surfaces are best for reflecting heat; and it has been shown by Professor Leslie, that brass is a more powerful reflector of heat than steel, and consequently better adapted for the ornaments round a fire-place. Glazed surfaces of a light colour are good reflectors; and if covings were covered with Wedgwood-ware, of tasteful patterns, a greater quantity of heat would be reflected, and a new and lively appearance would be given to fire-places. I have mentioned a light colour, but perfect white should be avoided, because it is not so agreeable to the eye as other colours. To determine the position of the covings, HH, so that they shall be best adapted for reflecting

Fig. 52.



the heat of the flame into the room, we may consider F to be the focus of the fire; then, if D H form an angle of 45° with A F, the heat, from a portion of flame, at the focus F, would be reflected into the room in a direction perpendicular to the line D E, which here represents the front of the grate, the angle of incidence being equal to the angle of reflection, which is the condition required to be fulfilled. The same will be true of a portion of flame at any other part of the fire. Therefore, to set the covings so that they will reflect the heat with advantage into the room, make F the middle of the front of the grate, and F D half the width which is convenient for the opening; and make A E perpendicular, and equal to D E; then join A D, and it is the direction in which the coving should be placed. A greater obliquity would be still more effective, because it would spread the rays more into the room, but is not convenient in other respects. The back of the fire is usually straight; but, unless the fire be small, it is an advantage to make the back in two parts, forming an obtuse angle at *e:* in this angle, the smoke collects and ascends with less obstruction than when it is dispersed over a flat surface. It is not necessary that the form of the fire should be regulated by the position of the covings, because its form does not affect the reflection; on the contrary, acute angles should be avoided, and the fuel kept as much in mass as possible. The form for the fire, marked *a b c d,* in the figure, is drawn with the angles acute, as they ever should be made."

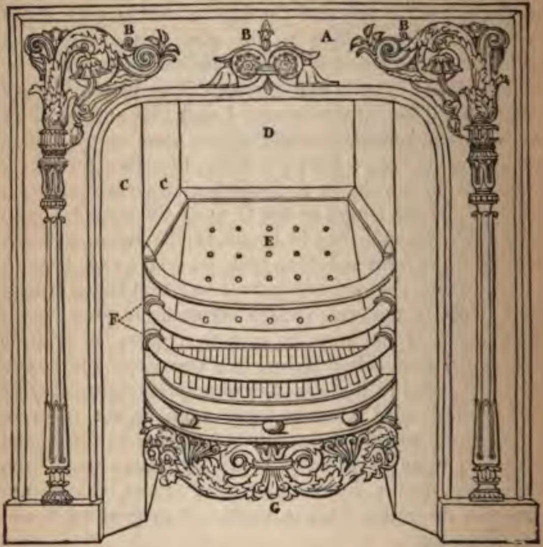
The same intelligent and experienced writer gives the following additional formula, in reference to open stoves: — "The height of the grate from the floor of the room is an object of some importance; if it be placed too low, the heat is expended almost wholly on the hearth, and the fire-place seems buried within the fender. If it be placed too high, a person's face is scorched, while too small a portion of heat is given to the floor, to render a room comfortable; but a high mantel has some advantage, in producing a more effectual ventilation. After an attentive consideration of the reasons which determine this point, I am of opinion that the top bar of a grate should not be less than twenty inches from the floor; nor, perhaps, will it be desirable to exceed two feet. And when the lower part of the fire is not buried in a mass of metal-work, there will be an abundant supply of heat thrown on the floor, with the greater height. The space between the top bar and the mantel will require to be proportioned according to the size of the room and draught of the chimney, and, in ordinary cases, may be about fifteen or sixteen inches. The proportions of grates for different-sized rooms I shall give entirely from observation, because it would require some more accurate experiments than I have yet made, to reduce these proportions to a rule, by an investigation from first principles. If the length of the front of the grate be made one inch, for each foot in length of the room, and the depth of the front be half an inch, for each foot in breadth of the room, the proportions will be found tolerably near the truth, in the cases usually occurring in practice. If the length of the room be such as requires the grate to be longer than thirty inches, two fire-places will be necessary; and in that case the same proportions may be adopted, divided into two grates: unless the room be very wide, when a greater length should be given, and less depth, so as to preserve an equivalent area." In the manufacture, however, of stove ranges for sale, numerous deviations from this scale of proportions necessarily occur.

The engraving annexed (*fig.* 53.) represents a complete Register stove, of a modern and fashionable pattern.

A is the front of the stove, generally cast in a single plate, and fitting within the jambs, or chimney bottom: in this pattern it is a perfectly flat surface, and may either be plated with polished steel, or be got up on the grindstone, and afterwards dressed with emery, to a handsome dead ground or silvery appearance, which gives excellent effect to the other parts. The lines running parallel with the outer and inner margin of the front represent a polished steel bead attached to the surface, and producing, with the dead ground, an exceedingly harmonious effect.

B B B, the front ornaments. These are designs in basso-relievo, often most beautifully cast and finished,

Fig. 53.



either in lackered brass, bronze, or verd antique. As these ornaments constitute one of the most variable features of the stove, the diversity exhibited in the trade is of course very great. They may either be permanently attached to the front, or made to take off; the latter being invariably the practice when the surface upon which they lie is bright; this arrangement affords great facility and convenience to servants in cleaning the parts. In more common sorts of register fronts, which are got up with black lead exclusively, these ornaments are cast with the front itself.

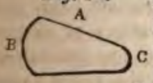
C C, the cheeks of the stove; the outer plate at least of which is usually more or less inclined, or coved, to reflect the heat.

D, the outside back, consisting of a plate which completely covers the stove behind. On the upper part of this back, and the top of the cheeks, rests the plate, with a small trap door or register, from which the stove is designated.

E, inside back, is a cast-metal plate, with air-holes. It not only prevents the main back, upon which the stove substantially depends, from liability to crack from contact with the fire; but it is so placed, that a current of air is constantly passing from beneath the grate, and between these backs, so as materially to assist combustion, as well as in some degree to keep the metal cool.

F, the bars. These may either be made fast to the cheeks, or, as is more commonly the case, in the better sorts of stoves they are made to "hook off," by means of side pieces with projecting pegs, made to fit into corresponding holes in the cheeks. This contrivance not only affords a great facility for cleaning the stove when fixed, but more particularly it allows the elegant conveniency of duplicate grates; a set of useful economical bars, in which the fire may be kept during winter or on other occasions, being superseded, during the summer months, or when a fire is not required to be kept, by a polished steel or other ornamental front. These bars may be made of various patterns, according to the taste of the manufacturer, or the preference of the purchaser, either plain, oval, London oblong, octagon, or straight; and with or without banister swells. In order that a grate may offer as little obstruction as possible to the radiation of heat from the fire, the bars should not be more bulky than is necessary for strength and symmetry. The form of bar recommended by Mr. Tredgold is indicated by the section in *fig.* 54.; in

Fig. 54.



which B is the front of the bar; and C, the part next the fuel; cinders falling on the upper side, A, would not roll out at the front; and there is evident advantage in offering less obstruction to the radiation of heat. Sometimes for wood fires the upper bar is furnished with obtuse spikes; and, latterly, many elegant stoves have been manufactured with vertical bars.

G, the fret, an ornament, either of open filigree work, or cast in bold relief, and denominated, according to its character, scroll, leafage, cable, &c. It is placed immediately beneath the lowest bar or fret-rail, and in the best kind of stoves it is made stationary, but in the more common black work it is cast in a single piece with the lift of bars. The fronts of register stoves vary materially in their size and proportions, according to the expense or the conveniences for their erection: the most common width of the fire-place is about eighteen inches.

The half-register stove differs from the foregoing one in being without the metal front, and open above the fire-place. The spaces between the bars and the chimney jambs are occupied by hollow cubes or pilasters rising to the upper or hanging bar, and surmounted with iron plates called *hobs*, or *hoods*. The side pieces of this class of stoves are often very richly ornamented in front; and the outer back plate terminate in scroll-work or other rich designs cast thereupon. These stoves are on the average about three feet wide in front; their value being one third less than full registers got up in the same style. Occasionally, though but seldom, the two descriptions of stoves are united, under the designation of the registered half-register.

Besides the open fire-places, which radiate heat, and which are manufactured in such a variety of elegant forms to suit the means or the taste of purchasers, we have to notice another heavy article in the same line of business, namely, the close fire-places, or *stoves* properly so called, and the principle of which is the emission of hot air. For stoves of this description we are indebted chiefly to Russia, Sweden, and Germany; necessity having naturally rendered the inhabitants of the North more attentive to the article of fires than those of more temperate climates. They were, likewise, addicted by habit to prefer in their apartments an intense heat to the pleasure of seeing the fire; a feeling quite opposed to that which always prevailed in England, where the sight of the blazing fuel appears almost to have compensated, in some cases, for the deficiency of heat.

M. Morveau, a Frenchman, who, thirty years ago, investigated the principles of foreign stoves with a view to national advantages, mentions the writers who had preceded him on that subject. The earliest name in his list is Francis Kesler, of Frankfort, whose work, entitled *Epargne-Bois*, &c. (the Wood-Saver, &c.), appeared in French in 1619: he is the first writer who deserves to be quoted as having proposed any useful ideas on this subject. In his stoves he formed eight chambers, one above another, through which the smoke was to pass before it entered the chimney. He also brought air directly from the ash-pan to feed the fire; and there was another aperture to draw air from the apartment for the same purpose.

Dolesme, in 1686, suggested the first idea of a stove without smoke, or more properly one, the smoke of which was not emitted, which he called *furnus acapnos*. Here the smoke is forced to descend into the fire-place, where it is consumed. Dr. Franklin, who afterwards executed a stove on that principle, still spoke of it in 1773 as a mere curiosity or philosophical experiment, as it required too much attention to be managed by common servants.

Gauger, the author of *La Mécanique du Feu*, &c. printed at Paris in 1713, and a translation of which was published in London in 1716, is considered to be the individual to whom we are indebted for the first and most complete treatise on the circulation of heat, air-holes affording warm air, the manner of making one fire warm several rooms, and the emission of heat in elliptic curves. He first suggested the plan, now common, of placing the sides or covings of a fire-place in an oblique direction; a plan, however, more generally attributed to count Rumford, as Gauger's work does not appear to have attracted much attention in this country.

To Montalembert is attributed the first idea of introducing into France stoves constructed in imitation of those used in Russia, in which the smoke circulated in ascending and descending flues. In the memoir he read on this subject to the Academy of Sciences in 1767, he called them *cheminées poêles*. Several of these were executed at Paris; and even Russian workmen were brought thither, in order more surely to obtain every advantage their method afforded. *Fig.* 55. and *fig.* 56. exhibit a section and profile of a stove of the above description, which, although well enough suited to the wants of those northern nations where an elevated temperature is chiefly regarded, has been considered objectionable on two accounts: in the first place, the fire is not seen; and, what is worse, the air of a room, when heated by such a stove, is found to be disagreeable and

Fig. 55.

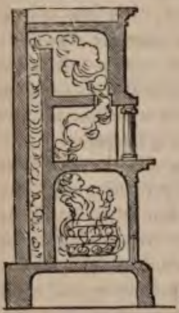
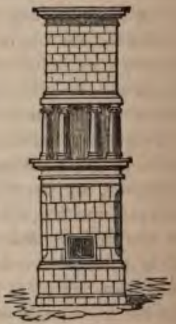


Fig. 56.



injurious. To prevent evil effects, it has been recommended to place a vessel of water upon the stove, which has the effect of saturating the air with vapour: this practice Mr. Murray found to obtain with the Italians among the Apennines. On enquiring the reason, he was repeatedly assured, that without it they would be subject to headach and other indispositions; while, with this simple precaution, they experienced no inconvenience whatever.

The Chinese warm their rooms by means of stoves, ovens, and furnaces, of which they have several sorts: those called *kang* are described by father Gramont. The kang is a kind of stove heated by a furnace. It consists of the following varieties: — the kang with a pavement, or ti-kang; the kang for sitting people, or koa-kang; and that with a chimney, or tong-kang. As they are all made on the same principle, the description of the koa-kang may not be unacceptable. The parts of a kang are, 1st, the furnace; 2d, a pipe for the heat; 3rd, a brick stove; 4th, two funnels for the smoke. The furnace is proportioned to the size of the stove it is intended to heat. The lowest part is the ash-hole; next, the cellar; then the furnace, having a slit or mouth that conveys the flame and heat into the stove by a pipe or conductor, beginning at the mouth of the furnace, and forming a channel which falls in a right angle on a second, that goes quite through under the middle of the floor; and this last pipe has vent holes here and there. The stove is a pavement made of bricks, which, being supported at the four corners by little solid piles, leaves a hollow space between them and the under pavement, where the heat remains pent up, and warms the floor.

The smoke funnels are at both ends, with a little opening on the stove, and another outwards, which carries off the smoke. The furnace may be placed either in the room itself, or in the next room, or without doors. The poor, who are glad to make the most of the firing that warms the koa-kang, on which they sit by day and sleep by night, place the furnace in the same room; the middling sort put it in an adjoining room; the rich and great have it on the outside, and most commonly behind the north wall. The furnace is much below the level of the stove, that the heat and flame may ascend with the greater impetuosity into the conductor, and not drive up the ashes.

The Chinese, like the Germans, always keep standing in the room bowls of water that are heated by a coal fire; and gold-fishes are generally kept in them for ornament. In the palace the emperor's apartments are decorated with flower-pots, and little orange trees, &c. The Chinese philosophers pretend that this is the best way to sweeten the air and absorb the fiery particles dispersed in it. The poor often enclose within the brickwork of the kang a vessel either of copper tinned, or of iron, which supplies them with hot water for their tea.

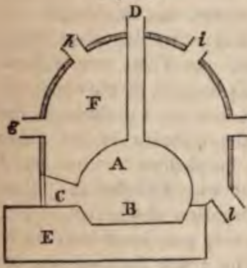
The unpleasant effluvia arising from many sorts of close metal stoves consists of what is commonly called *burnt air*. The best cure for this evil consists in confining the burning fuel within a proper thickness of matter, generally of a slowly-conducting power. "Common bricks," says Tredgold, "are not proper, because they contain sulphurous matter, which sublimes at a low temperature; they are also liable to open at the joints from the expansion of the heated air in the flues, and which very frequently breaks the solid bricks. It would be not difficult to obviate this fault; for if a case of iron were contrived in such a manner that it would not break by irregular expansion, and be perfectly air-tight, with a lining of brick of such a thickness and extent as would limit the temperature of the surface of the iron to 212°, it would form an excellent stove. A stove of this kind, when insulated, so as to experience no loss of heat, and with sufficient length of flue to obtain the whole effect of the fuel, will be very effective. The various forms of stoves called Swedish are only variations of this principle, where a case of glazed tiles is used instead of a case of metal; and there has not always been strict attention paid to limiting the temperature of the surface for heating the air. When Guyton-Morveau investigated the Swedish stoves, with the view of introducing them in France, he so far deviated from his models as to heat part of the air by iron plates that were in contact with the burning fuel; and, consequently, made them liable to the worst objection against the German stove, that is, of producing burnt air."

About fifty years ago the close pyramidal stove was introduced into churches, halls, shops, &c. As it was liable to become red hot, and of course merely heated the air, without changing or circulating it, the objection above alluded to, namely, the burning of the air, was justly chargeable against it. The capital improvement of warming a room, by means of air, the temperature of which was raised by flowing through the heated cavities of the stoves, was materially advanced by the cast-iron or Pennsylvanian fire-places, recommended by Dr. Franklin. In 1780, two of these stoves were placed in St. John's church, Southwark, the funnels of which were carried straight up through the galleries and roof: before the introduction of these stoves, it had been usual to employ women on every Sunday morning with cloths to wipe and dry the pillars and walls before the congregation assembled. The warming of this place of worship was considered to be more perfect than any preceding; the plan was generally adopted; and the introduction of these or other stoves, with pipes of every degree of danger, ugliness, and contortion, has since taken place in most of our old churches.

The principle recommended by Franklin has been adopted generally in the modern hot-air stoves. These, instead of consisting simply of a cast-iron box, are constructed with a casing, or, as it were, of two boxes, one within the other, with a space between them through which, by means of proper apertures, the air is made to circulate; the emission of the heated current being regulated by a slide or rayed ventilator inserted at the top of the stove.

Churches, manufactories, and other large buildings are now commonly heated by means of a cockle, which was first applied with effect by the Messrs. Strutt, in their extensive cotton mills at Belper in Derbyshire. The cockle is a capacious vessel, made either of cast-iron or of plates rivetted together in the manner of a steam-engine boiler, and is so set, that a fire can be made withinside it, upon a sunk grate, the smoke of which passes by a flue into the chimney. This cockle is enclosed in a casing of fire-bricks, so built up as to form an air-chamber from which, by means of tubes, the heat generated in this apartment is carried to the rooms where the warmth is wanted, and admitted by ventilators placed in the floor. A (*fig.* 57.) represents a section of the cockle; B, the grated cavity in which the fire is made; C, the fire-hole, or opening for the introduction of fuel; D, the flue, to carry off the smoke; E, the ash-pit; F, the air-chamber; *ghik*, pipes passing from the chamber to the apartments to be warmed; *l*, a pipe for the admission of fresh air from without, which constantly rushes in and supplies the vacuum produced by the rarefaction of the air which is thereby driven through the tubes. In using this apparatus, care is required that the cockle does not become so much heated as to burn the air, and thus produce a disagreeable smell. Air heated by contact with hot iron becomes dry, has its electrical condition altered, and by the decomposition of the organic matters floating in it, an unpleasant smell is given out.

Fig. 57.



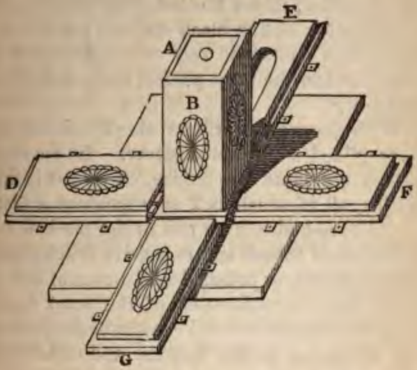
Not only steam but hot water has of late years been applied successfully for warming churches, &c. The north of England Joint Stock Bank, at the front of the Royal Arcade, at Newcastle upon Tyne, is warmed on this principle by an ingenious apparatus, constructed by Messrs. Walker of that town. By means of a sort of inverted double pan, or water cockle, as it might be called, which is fixed in a furnace in a low room, a constant ebullition of the water is sustained, and the fluid, at a high temperature, is made to circulate through a range of low cast-iron coffers, running behind the desks in the banking apartments.

The use of hot-water as a means of warming large buildings has been very much extended within the last few years. The most simple apparatus is constructed on the principle that hot water having less specific gravity than cold, ascends; therefore, the water being heated in the boiler, rises to the highest level, while that which has parted with its heat returns to the lowest level, a circulating system being thus completely established.

Stoves, including every description of metal fire-places, close and open, constitute one of the most extensive, superb, and profitable manufactures of the country. All the parts are cast in fine sand, from models made very smooth and exact. To produce a casting, the moulder takes a frame which is shallow or deep, according to the size of the article to be included. The model being placed with the ornamented surface uppermost, on a level board, it is well powdered over with fine dried pulverised sand. The frame is then placed over. The casting sand, a little moistened, so as to make it cohere, is shovelled in, and with a rammer, beaten firmly down upon the model, more sand being put into the frame or box, until it is completely filled; the sand above the margin is then sliced off with a strike, or straight wand, and the frame containing the sand and model turned over upon the board. The reverse side of the model being now presented, it is powdered with dust from the bag as before, and another frame being placed upon the former one, to which it is exactly fitted by means of pins and projecting ears, the inside is filled and rammed with sand as in the first instance. The boxes are then separated, and the model taken out of the sand, which retains a fine sharp impression of the said model. The surface of the sand is, in the next place, dredged over with bean-flour, and afterwards with powdered charcoal; the surface, where smooth, being polished over with a flat tool. A gutter being now carried to the edge of the sand in a corresponding part of both moulds, or a hole made through the uppermost only, the boxes are closed, and detained in their position by weights or clamps, while the metal is poured in by means of a large ladle. By means of this treatment of the moulds, the casting comes out clean and smart; as the bean flour, by burning away, and leaving the charcoal prevents the sand from adhering to the surface of the metal. If the metal be of good quality, in a proper state of liquidity, and the process of moulding adroitly managed, the casting will be remarkably perfect and smooth.

In casting at once the body of a hot-air stove, the following ingenious contrivance is resorted to:—A square plate or board of the area of the bottom of the article to be cast is prepared, having a pair of hooks projecting from each of the edges; these hooks receive the hinges of four iron frames, each of a proper size to mould one side of the stove, and removable at pleasure for that purpose. To produce a casting, the workman places upon the plate or foundation a square box, made smooth inside, and slightly tapering upward: when this box has been filled with sand, well rammed down, and levelled at the top, A (*fig.* 58.), the model ornaments B C are attached to the sides by means of little pegs or projections; the four iron frames above mentioned, with their under boards, are then brought up and fastened, so as to form a complete closure about the box inside, with the exception of a space to receive the sand: this space having been carefully filled with sand, the sides are loosened, and laid down as in the figure; the models are removed, the box is then carefully withdrawn, an operation which its taper form is intended to facilitate: a cubical cove of sand is thus presented, of a size corresponding with the internal dimensions of the article to be cast. The side plates and door-place having been moulded in the several frames respectively, they are taken and examined, and corrected by the moulder, after which they are carried upon their boards, and again attached by means of the hinges to the foundation, already described, and lying in the position indicated by D E F G. These four mould boxes are then finally lifted up so as to form a closure about the case, an intermediate space being left for the reception of the metal, which is poured in through a hole at the top, after the whole case has been properly adjusted, bound together, and every outlet closed up with sand.

Fig. 58.



Articles of this class having many of their parts ornamented with relief-work, to which the usual processes of getting up a smooth surface cannot be applied, are mostly finished in the black style common to ordinary fire-places. During the operation of fitting up or putting together, files or chisels are used for the removal of any knots or flaws, after which the surface of the metal is well covered with a mixture of black lead and water, and in the next place brushed until it assumes a good ground and deep lustre, resembling the effect sought to be produced by kitchen-maids upon similar articles.

The principal part of the register-stoves, and others of the same class, may be distributed, as to their ornamental character, under the following descriptions:—

1. Consisting of fine black castings; which are often produced from models of very rich and elegant designs, and combined in the most perfect and admirable style of workmanship.

2. With japanned surfaces of all colours and mixtures, or gilded with gold or silver. In general, however, they are black or bronze, or veined in imitation of marble, all of which look very handsome, last a long time, and have had a large run in the market.

3. The most superb and expensive articles, composed of ground, glazed, or polished steel stoves of this description, are often manufactured of the most magnificent patterns and dimensions, and constitute the principal feature of attraction in the London and Sheffield show-rooms.

4. Brass fronts, or combinations of brass work, either lackered or bronzed, with all the above-named surfaces.

The principal pieces of a stove are cast in good metal, in order that they may admit of being filed, drilled, &c. by the fitters up; and, moreover, that the surfaces which have been ground or polished may be free from flaws. When bad metal is used, or even that which is too rich in heavy articles, it makes bubbles in the casting; and the surface, when wrought, has a fretted appearance, or, as the workmen say, is *kishy*. This defect often occasions much inconvenience to the fitters, as it does not always become visible until considerable labour may have been expended in getting up the surface of a large article. In some instances, the holes admit of being plugged with bits of metal; a course which leaves, perhaps, the surface even, but, from a difference of colour or other causes, the patching is generally so apparent as to become an eyesore in fine stoves: the fret or screen at the bottom of the grate, and all the filigree ornaments, are cast of the best soft metal, to prevent their breaking.

Of late the fashion of stove fronts has turned mostly upon a dead bright iron ground, inlaid with polished steel, and overlaid with burnished brass, or bronze foliature, or scroll-work. The iron surface is got up by an application of the grinding stone, to bring about a smooth bottom; after which a hand rubbing with flour, emery, and oil gives it that peculiarly silvery appearance which, in contrast with the bright steel and bronze ornaments, has so good an effect. These latter ornaments are generally attached by means of springs, or some similar contrivance, so as to admit of being removed either for convenience or for re-bronzing.

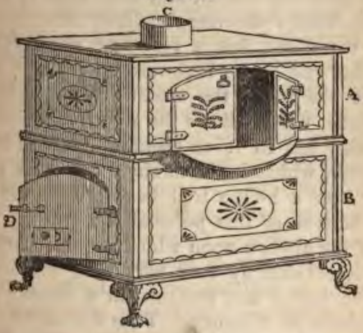
The forms and ornaments of these articles are perpetually varying, as caprice or science may happen to influence the designer. A few London houses make up superb stoves, for the residences of the nobility, from drawings of first-rate architects; and some of the stove-grate manufacturers in the country employ, at a considerable expense, draughtsmen in making designs for new patterns, in some of which no small degree of taste and ingenuity is evinced. Although in these cases the artist, of course, is the actual delineator, much, after all, depends upon the judgment and experience of the principal; for, however the fancy or the knowledge of the artist may enable him to invent or to combine, they do not often qualify him in the same degree to decide either how far an ornament, which looks well on paper, may be likely to take when actually cast in metal, nor always whether it be exactly proper for the purpose intended. On the other hand, if the master want spirit, taste, or money, to patronise new and ingenious designs, it is in vain that his designer tax his invention, when whatever of originality his designs may exhibit will be sure to be frittered down into common-place productions. Some idea may be formed of the importance attaching to this department, when it is stated, that even in the country from 20*l.* to 50*l.* is not unfrequently expended upon the models of ornaments for a single stove.

The introduction of Schools of Design in our manufacturing districts has tended materially to improve all kinds of ornamental metal manufacture, and no department has profited more than the stove and stove-grate manufactory.

The method of producing the model, in the first instance, is as follows:—The artist makes a drawing on a small scale, and finishes it, so as to exhibit, as nearly as possible upon paper, the effect intended to be produced. If approved by the manufacturer, the draughtsman copies it in outline, of the actual size, and bearing all the proportions of the projected article. This sketch is sent to the modeller, who, having laid upon a board a sufficient bed of finely-tempered clay, the surface of which is made smooth, he places upon it the paper, and transfers the outline of the figure, by tracing it over with a blunt point, or pricking it through at short intervals with a needle. When, by this means, the sketch is transferred, the paper is removed, and the modeller proceeds, with the assistance of appropriate tools, first to cut away the margin, and in the next place to carve out the deep and elevate the prominent parts, according to his copy; repeatedly touching up and improving the work, until it exhibit the requisite spirit and finish. A cast of gypsum, or plaster of Paris, is then carefully taken from the clay, and from the gypsum matrix a casting of lead, which serves as the model from which to obtain a hard-metal casting in moulders' sand: this, being properly cut up with chisels, and dressed to make it smooth, is the regular pattern to be used in the foundery. It need hardly be added, that where so much depends upon new and handsome patterns, while the expense and trouble of originating them are so considerable, that piracies are not unfrequent. In respectable houses, a principle of honour prevents this sort of nefariousness; but, where a want of integrity or the temptation of necessity exists, it is not an uncommon thing for parties to purchase a finished stove, take it to pieces, and use the various pieces as models to cast from.

The Russians and the Germans make their own stoves; and we have no trade of this kind to France: so that all the stoves manufactured in this country are for home use, except a few, which, under the designation of Canadian stoves, are exported to British North America. The Canadian stove (*fig.* 59.) consists of two chests, A, B, composed of cast-iron plates, and either piled one upon the other, or used separately, as circumstances may require. When set up, as represented in the engraving, the upper chamber A, which is cast with flues, passing from the fire-place below to the chimney C, is intended to be used as an oven, the fuel being supplied by the door D. When intended only for warmth, the upper part is removed, and the top plate, with its chimney, placed upon the lower chest. The stove is composed entirely of plates, so that it may conveniently be taken to pieces, and packed in a waggon

Fig. 59.



during excursions, and, when wanted, a few minutes serve to reconstruct it in the wilderness.

A stove, Joyce's patent, was introduced a few years since, in which charcoal soaked in carbonate of soda was employed. The stove was an urn, and all the heat of combustion escaped into the room; but at the same time all the products of that combustion, as carbonic acid, which rendered them highly dangerous.

In 1785, Dr. Franklin published a description of a stove, in which the flame was reversed, or passed downward through the fuel, so as to consume the whole or the greater part of the smoke. The appearance of this stove is that of a vase of cast-iron, with its pedestal; and this is mounted upon the top or lid of an air-box, standing upon the hearth, and built close in a recess in the mason-work: the vase, standing detached from the back of the niche, has a very neat appearance. The top of this vase opens backward on a hinge, like a lid, to admit the fuel; the opening being covered by a brass frame, which allows the air to enter: the bottom of the vase, has in it an opening of about two inches in diameter, which leads through the stem or foot of the vase into a hollow iron box, forming the pedestal. At the bottom of this pedestal is a grating, in the lid or top of the air-box upon which the vase stands. The air-box is divided by four partitions, between which the smoke passes and repasses, in a waving direction, until it enters the chimney. Thus the smoke and flame, immediately after it has descended through the grate in the top of the air-box, passes backwards towards the chimney, between the two middle partitions; but, as it cannot enter into the chimney at that part, it turns round the ends of those partitions, and returns in two currents towards the front of the box, then returns again round the ends of other partitions, and goes back into the chimney which is behind, or rather at the sides of, the niche in which the vase stands. The front plate of the air-box is made to slide in a groove, in two pieces, which meet together in the front, like folding-doors;

and these pieces being slided back expose the spaces between the partitions, which, as before mentioned, act as winding flues for the smoke to circulate in, and give out its heat through the metal of the air-box. In the space between the two middle partitions, and into which the smoke first descends, a drawer is fitted to receive the ashes or cinders which may fall through the grate in the top of the air-box, and it can be easily withdrawn to clear it out.

There is likewise a small grate at the lower part of the vase, upon which the fuel contained in the cavity will rest. When this fuel is lighted, the flame and smoke will draw downward, and, descending through the grate, will pass through the hole in the bottom of the vase into the hollow pedestal, and through the grate in the top of the air-box: it then passes horizontally in the space between the two middle partitions of the air-box, and proceeds in the same direction towards the back of the chimney; there dividing, when part of it turns to the right, and passes round the farther end of the middle partition; then coming forwards, it turns round the near end of the outside partition; then, moving backwards, it arrives at the opening into the bottom of one of the upright corner funnels, behind the niche, through which it ascends into the chimney; thus heating that half of the box, and that side of the niche. The other part of the divided flame passes to the left, round the far end of the middle partition, round the near end of the outside partition, and so into and up the other corner funnel; thus heating the other half of the box, and the other side of the recess. The vase itself and the box will also be very hot; and the air surrounding them being well heated, and rising, as it cannot get into the chimney it spreads in the room: colder air succeeding is warmed in its turn, rises and spreads, till, by the continual circulation, the whole is warmed. If there is occasion to make the fire when the chimney does not draw, it must not be kindled at once in the vase, but in one or more of the passages of the lower air-box, first withdrawing the sliding front of the air-box, and covering the mouth of the vase. After the chimney has drawn some time with the fire thus low, and begins to be a little warm, those passages may be closed, and another fire kindled in the hollow pedestal, leaving its sliding shutter a little open; and when it is found that the chimney, being warmed, draws forcibly, that passage may be shut, and the vase opened, to make the fire there, as above directed. The chimney, well warmed by the first day's fire, will continue to draw constantly all the winter, if the fire is made daily. The construction of this stove presents no difficulties to the manufacturer, and its appearance, in some situations, is very good; but the constant care required in its management, and especially the complete boxing-up of the fire, have prevented it from becoming a favourite in this country, though in France it has been much used.

The expression of burning smoke has been very generally misunderstood. Smoke is a mixture of the products of combustion, with water, and unconsumed carbonaceous matter, which form the black particles. The bituminous or free burning coals produce the greatest quantity of smoke, *i. e.*, of solid carbon in a state of fine division. If this black cloud is passed over a heated surface it is burnt, and consequently no *visible* vapour escapes, but it must be understood that we destroy nothing; the black coal, consisting in the main of carbon, is converted into carbonic acid, and this colourless gas, mixed with water, ammonia, &c., passes off into the air after the smoke is burned.

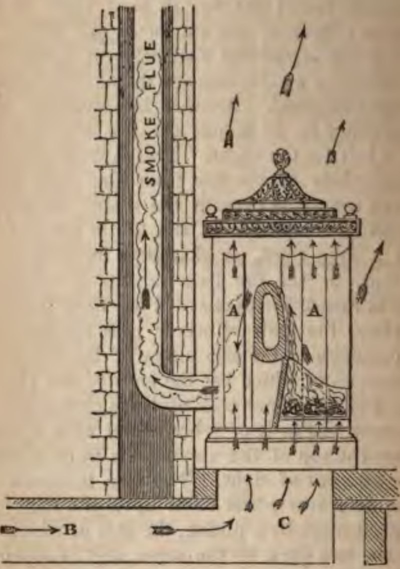
Dr. Franklin, during his residence in Paris, contrived another fire grate, calculated to consume its own smoke, which, for its ingenuity at least, deserves to be described. The grate is a short cylinder, with its axis placed horizontally; one end is turned towards the apartment, and made with bars — the other is a back plate: it is about one foot in diameter, and eight inches between the bars and the back. The sides are of plate iron, having holes of half an inch diameter, and three or four inches distant from each other, to let in air for enlivening the fire; the back is without holes. The side plates do not meet either at the top or bottom by eight inches, the interval being filled with small bars, passing from front to back, to admit air below, and let out smoke above. The three middle bars of the front or circular end of the grate are fixed; the upper and lower ones may be taken out and put in at will, when hot, with a pair of pincers. The whole of this cylindrical grate turns upon pivots fixed in the opposite sides, across the centre of it: the pivots are supported by a crotchet, the stem of which is an inverted conical table five inches deep, which fits as many inches upon a pin, which is fixed upright in a cast-iron plate that lies upon the hearth. In the middle of the top and bottom grates are knobs projecting about an inch, which, as the whole is turned on the pivots, stop it when the grate is perpendicular. By this means the grate can be inverted by turning it over upon its pivots; but, as that will present the back-plate to the apartment, it requires to be turned half round horizontally upon the conical pin, to bring the front bars to the room.

In making the first fire in the morning with this grate, there is nothing particular to be observed: it is made as in other grates, the coals being put into the cylinder, by taking out the upper bar, which is replaced when they are in. As the fire burns down, it leaves a vacancy above, which must be filled with fresh coals, the upper bar being removed, and replaced as before. The fresh coals, while the grate continues in the same position, will throw up, as usual, a body of thick smoke; but every one accustomed to coal fires in common grates must have observed that pieces of fresh coal stuck in below among the red coals have their smoke so heated that it becomes flame in its passage through the ignited cinders. This, then, is the phenomenon which suggested the principle of the swivel grate: by a push with the tongs or poker it can be turned over on its pivots till it is inverted, when the front bars face the back of the chimney: a gentle turn upon its vertical socket brings it again to face the room, when all the fresh coals will be found to be under the live ones, and the greater part of the smoke arising therefrom will, in its passage through the fire, be inflamed and consumed. By this means it is asserted that more heat is obtained from the fresh fuel, while that which is more ignited is longer preserved from being consumed. As an ingenious contrivance, this stove may be admired; but it can be no wonder that its complexity should have precluded even its partial adoption as a useful fire-place. Various contrivances have been announced, having for their object to supply the fresh fuel *under* the fire, and consequently to burn the greater part of the smoke, on the principle of Dr. Franklin's revolving grate. The advantages claimed for these contrivances are, first, that the combustible quality of the coal is turned to the best account: the smoke, instead of being suffered to pass up the chimney, is inflamed in its ascent, and thus contributes heat: secondly, the chance of a chimney smoking, so as to become annoying, is materially lessened, from the small quantity of air required to produce a draught: thirdly, the vent will rarely require to be swept; and, fourthly, the effect that such a mode of feeding fires, if generally adopted, must have in diminishing that mass of sooty particles which darkens the atmosphere of London and several large towns. Such advantages were enumerated to the public, in recommendation of a contrivance for the purpose above mentioned, for which a patent was, in 1815, granted to Mr. Cutler, of London. His plan consisted in applying to a register stove a chamber or magazine, situated beneath the grate (or the space enclosed by grating) in which the fire is to burn. This chamber is to contain a magazine of fuel, sufficient to supply the combustion for a whole day, or other required space of time: the bottom-plate of the chamber is movable; and, by means of a wheel and axle, the fuel contained in the magazine can be elevated, so as to introduce a portion of the fuel into the grate at the lower part, or from beneath; and thus from time to time replace the fuel which is consumed, without the trouble of occasionally throwing on coals. In order to make the fire burn, the flue, or entrance to the chimney, must be of such a construction as will produce the most efficient draught or current of air to pass through and across the top of the fire. The introducing a supply of fuel into the grate from beneath causes the fire to burn clear, and with little smoke; because the smoke or gas which issues from the newly introduced fuel, when it is first heated, must of necessity ascend through the burning mass, and be thereby consumed. Another improvement asserted by the patentee is, to reduce the fire or extinguish it, when it is left for the night. This is done by lowering down the whole of the fire from the grate into the chamber or magazine beneath the grate: the supply of air is thus interrupted, and the fire is completely enclosed in a deep chest, so that it is impossible sparks can fly out, or the fire long remain unextinguished. The fuel is raised by means of a bar fixed beneath the bottom plate, the ends of which pass through slits or narrow openings in the side plates of the chamber; to the extremities of which bar the ends of two chains are attached, and the upper ends of these chains are made to wind upon the ends of a horizontal axle, which extends over the top of the stove, so as to be within the chimney, and out of sight. The axle is turned round by a face or crown wheel fixed upon the extremity of it, and acted upon by a pinion, the axis of which comes through the ironwork of the stove, and is squared, so as to fit a key or small winch handle.

Amongst the more important improvements which have been made in stoves, are those of Dr. Arnott. In Arnott's stove a very ingenious contrivance is adopted for equalising the supply of air to the fire, and consequently of maintaining an uniform heat. This is effected by taking advantage of the expansion of mercury or of a bar of metal. As the heat increases, the metal expands, and in expanding closes a valve, and thus checks the supply of air. If the fire falls back, the metal in cooling contracts, and opening the valve, more air is supplied, and consequently the combustion increased.

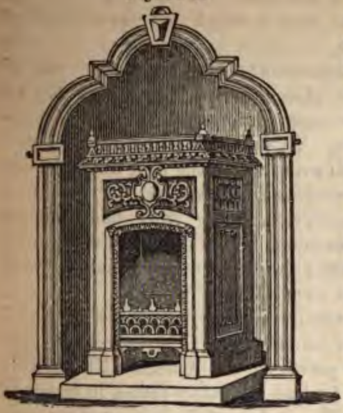
Pierce's Pyro-pneumatic stove is of a most ingenious construction. The object is to obtain in any apartment a constant supply of fresh warm air, while the deteriorated air is as easily removed, and this without any annoying draughts. The principle is to draw the supply of air from without the apartment, by an opening through the wall communicating with the external air, BC. The whole of the interior of the stove is formed of tubes or cells of Stourbridge clay, A A; these cells com-

Fig. 59 *a.*



municating with each other and circulating around the fire which is in the stove — an open one. The warm air flows out through the perforated metal top into the room in which it is placed, circulates around it, and losing its heat, descends and supplies the current, which is required to support the combustion of the coals in the fire-place.

Fig. 59 b.



The operation of this stove is as follows: — The fire is lighted, and in a short time the fire lump becoming warm parts with its heat to the air in the cells; this expanding and becoming specifically lighter, ascends, and cold air from without supplies its place. A free current is thus established, air is continually pouring into the apartment, warmed in its passage through the chambers of the stove, and the air from the apartment passes off by the fire-place as through an ordinary chimney.

The use of gas, which is rapidly increasing, has led to the employment of gas stoves for the purposes of warming and for cooking. To obtain a large quantity of heat, the gas is allowed to mix itself with common air, and then take fire: it burns with a pale blue flame, emitting very little light, but possessing great heating powers. This principle admits of many obvious variations, and it is employed for cooking with great economy and facility. Gas has been employed to ignite coils of platinum and asbestos, and thus produce the appearance of an open fire.

Ovens, Fenders, Fire-irons.

Closely connected, in demand and manufacture, with the kitchen-range or grate, may be mentioned the metal oven,—an economical fixture, which the conveniences of modern housekeeping, especially in the country, has now rendered almost indispensable; and which the state of the iron-foundry has placed generally within reach of the means of the poorest person who builds a cottage for his own residence. To find a dwelling-house, however small, without an oven beside the fire, would be an exceedingly novel occurrence now-a-days. Previous to the last century, however, before iron had become cheap, and casting common, it was usual, in the poorer sort of cottages, to bake the bread upon a round stone, supported on a trevet over the fire.

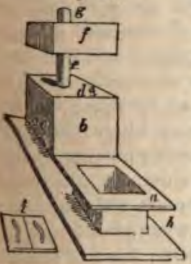
Early in the sixteenth century, portable ovens of baked clay were not uncommon. Stowe relates that "about the tenth yeere of the Queen (Elizabeth), Richard Dyer, after he had bin many yeeres in Spayne, where hee learned the making of earthen furnaces, earthen fier pottes, and earthen ovens, transportable, hee taught his countrymen the making of the same at London, without Moregate, and for a time enjoyed the whole profit thereof to himself by patent."

In the next century, farm-houses, and others of the better sort, had ovens of wrought iron; and to these succeeded the economical cast-iron ones now so generally seen. It was about the year 1770 that these conveniences began to be furnished by the founders in the north of England, and to be set with grates as we now see them; and some ten or a dozen years after that period, another and accompanying improvement was introduced, viz. cast-iron boilers, occupying the side of the ordinary fire-range, opposite to the oven, and covered with a lid serving as a hob; the heated water being either drawn off by means of a tap at the side, or laded out at the top. In common houses this boiler is very convenient, and not at all unsightly, always affording a supply of hot water for domestic purposes, without any necessity for choking the fire on every occasion with those great ugly pots or pans so incessantly introduced where the above-named convenience does not exist.

It has been one of the most successful achievements of modern ingenuity, in this line of business, to combine the kitchen-grate, oven, boilers, hot closet, steam kettles, &c., in one substantial and commodious fabric, or cooking apparatus, as it is generally called.

In the Repertory of Arts, a stove is described by the patentee to consist of an arrangement whereby he applies the known principle of supplying the air, which is to support the combustion of the fuel, to the surface of the latter, instead of from below; and, by causing it to pass downwards, to prevent any smoke, dust, or disagreeable vapour, which would otherwise arise. The receptacle for the fire is a cast-iron box, without a lid or bottom, fifteen inches square in the inside, thirteen inches high, and the metal two-thirds of an inch thick, flanged or spread out at the top, so as to form the margin *a* (*fig.* 60.). At the lower part of the front side of the box is an opening, for the purpose of introducing a shovel to take out the ashes: this opening might be dispensed with, but then it would be necessary to take out the ashes at the top, which would be much less convenient. This opening is to be shut by a small door, during all the time the fire is burning. At the back of the box there is a circular opening, six inches in diameter: to this opening the pipe or flue, *e*, is joined by an elbow, so as to carry the flame and smoke into the chimney. This box is placed on a plate of cast-iron, *h*, or pavement flag, on the chimney hearth. Inside the box is placed a horizontal grate, and upon this one or more grates, or plates, in a sloping direction, so as to form, between the fuel and the box, spaces for the

Fig. 60.



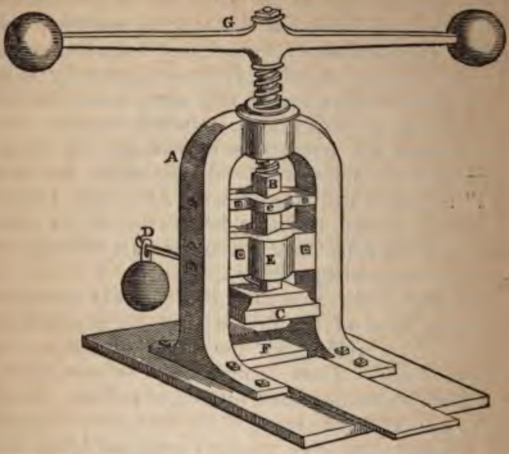
circulation of the draught. The draught, or current of air, which causes the fire to burn, draws downwards through the ignited fuel, and through the bottom grate upon which it rests, into the space beneath that grate, from whence it passes away by the smoke pipe or flue, as before described. The border plate is designed to support the culinary utensils, pots, saucepans, &c., where they will continue to boil. Behind the fire-box is placed a sort of stool, or frame, to support the boiler, *b*, which is made of copper or other metal, fourteen inches wide, one foot eleven inches high, and two feet long. A pipe of copper, five or six inches in diameter, open both at the top and bottom, passes vertically through the boiler, and is soldered to the middle of the top and bottom plates of the boiler, where it passes them: the top of the pipe rises about ten inches above the boiler. At the lower part of the boiler, *c*, is a cock to draw off the contained water, and at the top, *d*, a hole to pour in fresh water. The water is heated by the passing of the smoke and heat through the fore-mentioned copper tube, which terminates in the flue. The extremity of the vertical pipe, *e*, rises above the top of the boiler, and enters into an oven, *f*, composed of copper or iron plates, about two feet square, and one foot high. This oven contains another withinside of it, in the manner of a drawer, leaving an interstice of two inches on all sides, except the front, where the door opens into the oven; *g* is the conducting pipe for finally delivering the smoke or heat to the chimney. In using the apparatus, the box is filled with coals, and the cover-plate, *i*, or two kettles, which will, when placed side by side, just cover the opening of the box: the fire is then kindled by placing thereon a shovelful of burning charcoal or lighted wood, which sets the coals beneath it on fire. According to the patentee, "the fire continues without occasioning the least smell or smoke, because the current of air is drawn downwards through the whole mass of burning fuel; and, after passing down through the bottom grate, rises up again in the space left behind the sloping plate or grate, and from thence the smoke passes through the conducting pipe to the boiler and the oven, and ultimately to the chimney."

Next in importance to metal fire-places, as an article of domestic use, and at the same time of great extent and diversity of manufacture, may be mentioned the modern conveniences of fenders and fire-irons, especially the former. Fenders, however apparently indispensable now-a-days, are of still more recent use than the andirons, or metal grates; to which, however, they soon became the inseparable appendage. In ancient inventories we meet with "shovel, tongs, and fire-pan," but never with the fender. At present it would be difficult, indeed, to find a house containing a grate, without at the same time presenting its useful and appropriate companion, a fender.

The first fenders were mere bent pieces of sheet iron, placed in front of the fire, to prevent the brands, or cinders, from rolling off the hearthstone upon the wooden floors. These common articles were, in the first place, either blackened, painted, or polished, according to the taste or the means of the purchaser. Fashion and ingenuity, however, presently combined in the production of that elegant and standard ornament of the hearth, the polished cut steel fender.

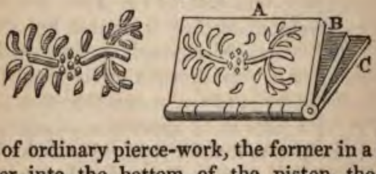
The rich and varied open work exhibited in some of these wares is produced by means of the fly-press, in the following ingenious manner: — The plate, whether of brass or steel, having been prepared by rolling and planishing to the proper strength, and cut with shears to the size required, is brought to the piercing-shop. Here is fixed a very stout fly, represented in *fig.* 61. A, the body, is eight inches thick about the shoulders, about four feet in height, and three feet wide at the bottom. B is a solid cube of steel, having attached to its lower end a platten, C, with a face five or six inches across, very level: this piece, instead of being attached to the bottom of the screw, as in the common fly-press, so as to rise and fall therewith, is separate, and can only be elevated by means of a forked and weighted lever, D, placed behind the body, and acting just underneath the cube or piston, so as to elevate it a little, on the withdrawal of the main screw, after each stroke. E *e* are guide pieces, to steady and direct the piston.

Fig. 61.



Instead of beds and punches, fastened as in the production of ordinary pierce-work, the former in a boss and the latter into the bottom of the piston, the fender-maker uses loose dies and perforated plates, answering to the figure intended to be produced. If the design be a flower, for example, the shape of the petals, the leaves, and the stem, is accurately perforated through a plate of steel, A (*fig.* 62.), from four to twelve inches square, and

Fig. 62.

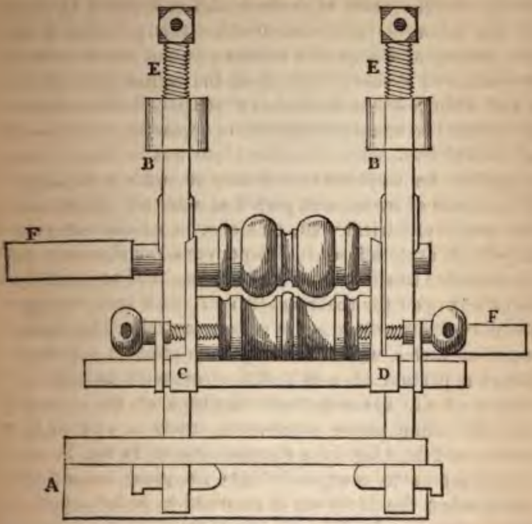


half an inch in thickness: another plate, B, of the same size, and in every other respect the counterpart of the former, is in like manner perforated. These plates are attached by means of a hinge, in such a way that every portion of the apertures shall perfectly correspond. Besides these, there is likewise attached, by the hinge, an unperforated iron plate, C, much thinner for the purpose of stopping the dies from falling through after each stroke. These dies, D (*fig.* 64.), are bits of steel, a little more than half an inch long, and filed so as to fit or slide through each separate part of the perforation with the utmost exactness: of course, these types, as they may be called, have their surfaces of the precise form of every petal, leaf, &c., designed to be cut out. To effect this end, a certain portion of the fender plate is placed between the jointed pieces, A B C, which are then brought together upon the intervening substance; the interstices are then filled by the insertion of the hardened steel dies above described, and the whole is placed upon the bed of the fly, F (*fig.* 61.). In preparing to make a stroke, the workman raises the screw by pushing back the ball, G, of the eight foot lever, after which he runs round with it in the opposite direction; so that by the time the bottom of the screw presses the cube with its platten upon the dies, a momentum has been obtained sufficient to force them at once through the intervening plate, carrying with them the bits which they respectively cut out. The tools are now taken out, cleared of the bits, the plate re-arranged, and another stroke made as before; which operation is repeated until the perforation of the plate is completed throughout its length.

The plate is then planished or levelled by hammering, after which it is sent to the grinding wheel to be got up on the stone, and afterwards it is polished with emery and crocus marti in a manner similar to the getting up of cutlery. The piercing of brass-faced fenders is effected exactly in the same manner as the perforation of the iron ones: the mode of getting up is likewise similar, only that the brass fronts are, when flat, buffed on a leather-covered wheel with sand, and when fluted they are brushed with rotten-stone and oil. The plates, previously plain or straight, are then bent into the shape desired, and the fender is finished by the rivetting of a tube of brass drawn upon an iron rod, along the top; and, in like manner, by the affixing of a moulding or plinth of brass upon the bottom, and then placing underneath the fender a plate of rolled iron. The whole is usually supported upon four lackered claw or ball feet.

The various descriptions of reeded and other swell-work, exhibited by some superb brass fenders, are raised upon the metal either by means of swaging with a hammer, rolling through grooved rollers, or stamping in a steel die: the last operation is generally resorted to when the work represents scrolls or figures, these being usually stamped one at a time, the metal being pushed along after each impression has been perfected, until the whole length is embossed. The Glasgow Mechanic's Magazine for 1831 contained the following figure and description of a machine for rolling fenders and grate bottoms, by Mr. Angus M'Kinnon, a manufacturer:— A (*fig.* 63.) the bottom, and B B the sides or uprights of the frame; C and D, guides, of which there are two on each side of the rollers, and which are moved by means of the screws which pass through them. When the machine is to be used, it is placed on an iron stand, or other support, about two feet and a half high, and fastened to the floor. The screws, E E, are then screwed upwards, to separate the rollers, so as to admit the flat plate of brass to be moulded; the end of the plate being inserted between the rollers, the screws, E E, are screwed down, and the rollers turned by means of handles attached to the square projecting ends, F F: by this operation the brass will be moulded according to the pattern upon the rollers. Should the moulding not be completely brought up after having gone once through, it is only necessary to screw the rollers tighter together, and pass it through until the accurate form be obtained. When the plate to be rolled is wider than common, the space may be enlarged by moving one of the uprights nearer to the end of the sole plate or bottom, A.

Fig. 63.



A variety of fenders, composed chiefly of reticulated wirework, having moulded tops and bottoms of bright metal, have been introduced: some of these have a light and elegant appearance; but as they do not admit of being conveniently cleaned, they are much seldomer composed of polished than of painted wire. This description of articles is more particularly adapted for those situations in which it is necessary to screen the fire, as a provision against the danger to be apprehended from the flying about of hot cinders, the approach of children, &c.

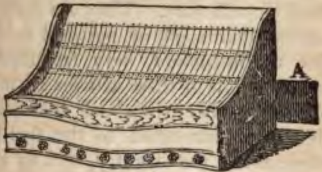
The numerous and fatal accidents occurring to children and others, in consequence of their approaching too near the bars of an open fire-place, have led to the adoption of screens and other contrivances having more or less the character of fenders, and calculated to fence in the burning fuel. More than thirty years since, Mr. Barns, of Glasgow, who had a patent for a stove in the shape of a vase or urn, included in his specification a contrivance of the kind above mentioned: it consisted of a glazed screen, or safeguard, of ironwork; the inside of the chimney, where the fire-place was to stand, being a sort of semi-cylinder, or nearly so, with a lining to cover made of metal, and placed at such a distance from the semi-cylindrical wall, or niche, in which the stove is placed, as to afford sufficient room for allowing the safeguard to be slipt round into it when the fire is wished to be left open for the reception of fresh fuel, or when the drawer with the ashes is to be removed. The framework of metal when filled up with glass or wirework, forms a portion of a cylinder, answerable to the curvature of the space between the back of the chimney and the lining above mentioned, made in one or two pieces, and moving in a circular groove in the hearth, which serves to conduct it into its place behind the grate, when the fire-place is required to be left open, as before mentioned. The top of the front of the opening, or chimney-piece, projects in a circular form, or is fitted with a projection of metal, having a circular groove on its under face, of the same radius as the groove in the hearth, for the purpose of guiding the upper part of the frame of the guard. The glass with which the frame of the guard is filled may be stained or painted, which, when the fire is burning, produces a pleasing effect. For nurseries and other rooms, where safety and convenience, rather than elegance, were to be considered, the frame of the screen was to be filled up with wirework.

In 1804, letters patent were granted to Thomas Jowett of London, for a fire-guard stove, the contrivance of which, as regarded the use of a screen to prevent sparks from flying out, was in principle very similar to the preceding invention. Mr. Jowett's stove is an upright cylinder, having the bars at the lower part, and an opening above for the admission of fuel: it is supported upon an iron bar or pedestal, which forms the axis of the stove, and upon which the guard is made to swing or revolve as a centre. This guard, like the former, is a semi-cylinder of wirework, balanced in its proper situation by means of two arms, or cranks, extending between the guard and the axis of the stove, and which support and direct the screen when brought before the fire, or carry it back to a recess left open for it to traverse behind the stove. It will be obvious that a guard of this description may be applied to almost any form of stove which will admit of corresponding pins or centre pivots being placed above and below for the support of the horizontal cranks. Besides the foregoing, we have seen stoves fitted with a curtain or apron composed of slips of perforated sheet metal, so arranged as to admit of being let down to cover the fire bars, or of being drawn up out of sight under the mantle by the touching of a small knob connected with the machinery, similar to that used in the spring window-blinds. There can be no doubt but each of the above-mentioned defences, as well as others that might be named, affixed to fire-places, would, if constantly attended to, afford security against the greater part of those awful deaths in consequence of the clothes of children and females taking fire, of which every week affords the memorials. But the danger, except in the case of children, is generally so hypothetical and unapparent, and, with ordinary caution, hardly any at all, — while the management and the appearance of screens are really unpleasant, — that few persons are willing to sacrifice so much of neatness and comfort as go to the paraphernalia and management of a guarded stove, even for the sake of absolute insurance against being burnt to death.

Within a very recent period a fender has been introduced to the notice of the public, which, combining, as it does, beauty, substantiality, and comparative cheapness, may be said well to merit the general approbation which it has met with. The body or wall of this fender is of cast iron, and may, consequently, not only be made to patterns varying through every gradation of design, from the richest relief to the simplest filigree; but it may also be got up in any degree of expensiveness, from common black lead to the best appearance of ormolu, verd antique, mosaic, or burnished gold. The most common method, however, of getting up these goods is by bronzing them, as it is called; and in this state, as well as more highly finished, they are exhibited, in the Sheffield show-rooms, at remarkably low prices.

Connected with the manufacture, as with the use of fenders in most places, may be mentioned the ash-pan, a sort of tray, one end of which passes under the grate, and the other fills the space between the inside of the fender-plate and a line perpendicular from the range, so that this receptacle catches whatever cinders and ashes fall through the grate while the fire is burning. It may appear unnecessary further to allude to a convenience so generally known and possessed; and yet this very simple contrivance exhibits, in a very striking manner, how happily science or art may render valuable tribute to comfort at a trifling expense. In the most superb rooms, and from the very richest grates, cinders and ashes will fall down, and sometimes in such a manner as exceedingly to foul the space withinside the fender; and who does not recollect, especially where the *mater domûs* was noted for cleanliness, having been more or less annoyed by the protracted and noisy operation of a servant with the fire-shovel, while removing the dust and coals from the hearthstone to the coalskip? By means of the tray alluded to, this annoyance is almost entirely obviated; the refuse of the grate falling into the pan is in a minute either carried away or shoved out of sight; and the maid with her dust-cloth now generally enters, and performs her duty, when at all, if not unseen, at least almost unheard. Some of these pans are made with parallel strips of polished steel, overlying one another like the ribs of a Venetian window, so that the ashes fall through and are not seen in the pan. The machine represented below, and called the economical receiver, obtained the approbation of the Society of Arts, as better adapted for the above-mentioned purpose than the common hearth-pan. It is a sort of high-backed box, composed of sheet iron, with ornamented front, and covered with a sloping roof of wirework; so that, on being placed under the fire-place, the ashes, on falling, are riddled or sifted through the grating, while the cinders fall into a receptacle in front, out of which they may be emptied upon the fire. A (*fig.* 64.) represents the slider by which the ashes are taken out.

Fig. 64.



By fire-irons, which it may be proper briefly to mention, the housekeeper and the ironmonger understand a fire-shovel, poker, and pair of tongs. These implements were not all of them found upon the ancient hearths of this country; nor were they all necessary when wood was burned upon a fire-place such as we have before described. In the time of Henry VIII. we find, in the inventory of a respectable housekeeper, that the only accompaniment of the "awnd-irons" was the "fyre forke." In the apartments, however, of the higher classes, the apparatus for trimming the fire were more complete; for instance, in the "perlar" (parlour) of a knight (sir Adrian Foskewe, 30th Hen. VIII.), we find "two large awnd-irons, a fyer forke, a fyer pan, and a payer of tonges." The use of these articles will be apparent. The use of pit coal, and of close fire-places, led to the adoption of the poker now in universal requisition. From a remark by Stowe, elsewhere quoted, to the effect that in the next reign but one began the making of "steel poking sticks," which were used by laundresses, one might almost be led to suppose that the ancient poker was no sooner made of metal than it was used for the same purpose as our modern Italian irons.

But to return to the fire-irons now commonly in use. These articles, although the indispensable appendages of the stove and the fender, belong, in general, to an entirely separate manufacture. They are made of common iron, of iron case-hardened, of polished steel; and, notwithstanding the misnomer, very frequently of brass. The commonest kinds of these articles are manufactured at and in the neighbourhood of Birmingham, from whence they are distributed to the furnishing ironmongers throughout the country, and by the latter retailed at singularly low prices. These cheap wares sometimes exhibit good proportions, and are ornamented with swells, raised by swaging with bosses, in the manner described in the chapter on whitesmithery: they are then filed, and afterwards got up at the grinding wheel, with rolling on the stone, and the application of emery and oil, by means of a circular brush. The most expensive description of fire-irons are forged out of good steel, or at least out of a better material than common iron, but in a manner similar to the foregoing; after which, all the swells and ornamented parts are carefully turned at the lathe. They are then, if of iron, case-hardened, and subsequently brought to that beautiful polish which some of them bear, by a process analogous to that of finishing razor blades.

The brass articles look very neat when well made, and are easily kept clean; but, as the shanks consist of tubes of brass covering iron rods, and screwed together at the swells, they are liable to get loose and shambling, unless carefully managed by those who have them in charge.

The fire-irons, instead of lying down flat upon the fender, as formerly, are now generally reared upright at each end against two standards, having near their upper ends crooks to receive the handles of the implements. This is not only a novel but a neat and convenient addition: it certainly enhances the original cost of the fender; not more, however, than it improves the article; so that, latterly, few of the better sort of fenders have been made without this addition.

CHAP. VIII.

IRON PRINTING MACHINERY.

BRIEF DESCRIPTION OF OLD WOODEN PRESS. — IMPROVEMENT BY EARL STANHOPE. — PERFECTION IN THE MANUFACTURE OF IRON PRESSES. — THE COLUMBIAN PRESS — ITS GREAT POWER. — ALBION PRESS. — IMPERIAL PRESS. — RUTHVEN'S PRESS. — MEDHURST'S PRINCIPLE. — ROTATORY PRINTING MACHINES. — NICHOLSON. — KÖNIG. — EXTRACT FROM "TYPOGRAPHIA," WITH REMARKS THEREON. — DR. GREGORY'S OBSERVATIONS ON MACHINE PRINTING. — COWPER AND APPLEGATH'S PATENT MACHINES. — OPERATION OF STEAM PRINTING MACHINERY. — TYPE CARRIAGE. — INKING APPARATUS. — DONKIN AND BACON'S MACHINE.

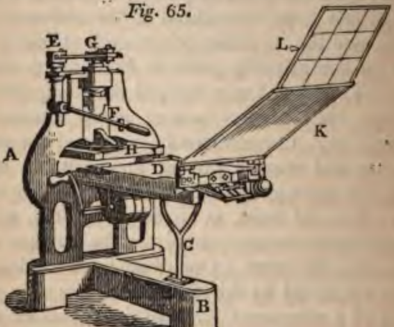
To give a detailed account of the invention of the printing press would hardly be more in place in this volume than would be the introduction of an abridgment of the history of typography itself. It would, however, be equally improper to omit, in such a treatise as the present, all mention of an instrument which, whether regarded merely as to the substitution of iron for wood, in the simplest form of its construction, or considered in relation to those complex machines which can only be made of metal, has afforded such large scope for the exercise of ingenuity, and so wide a field of manufacture in the business of ironworking.

Until a very recent period, the printing presses commonly used in this country differed but little in their form and materials from those known in Europe very soon after the invention of printing, almost four centuries ago. They consisted of two upright cheeks of wood, with stout-cross pieces, in which worked an iron screw, very similar to that of the fly-press now so generally known: to certain tackle, at the lower part of this screw, was suspended a square smooth-faced table of mahogany or other hard wood, occasionally faced with iron, and called the *platten*, by means of which, when pressed down by the screw, which was itself operated upon by the bar or lever handle, an impression on one side of an interposed sheet of damp paper was taken from the inked surface of the connected mass of types standing underneath it. The *form*, as it is called, or collection of types, properly arranged and confined by quoins or wedges within an iron frame, denominated a chase, was placed upon a level stone, fixed in a wooden bed or carriage, and made to slide backwards and forwards, upon a sort of railway under the platten, by means of a strap passing over a pulley, underneath the carriage, and connected with a winch handle, placed beside the horizontal parallel rails alluded to. The foregoing, in as few words as possible, is a description of the old-fashioned printing presses formerly found in this country; at least, in most offices beyond the metropolis. These wooden presses are now to be met with only in the lowest jobbing offices: the newspaper and other printers on a large scale invariably using one or other, and often more, of the numerous and excellent iron machines which have been of late years introduced to the notice of the trade.

We owe the invention of the earliest signal improvement in the printing press, in England, to the late earl Stanhope, who not only devised the admirable structure, to which his name has been so justly attached, but, as we may say, unintentionally suggested an experiment upon the old wooden presses previously in use, which led to the more general appreciation of the new metal ones. The old press, as already intimated, was made to produce an impression, simply by the action of a common lever upon the screw. One of the most striking improvements exhibited by the Stanhope press was the application of a compound leverage, by means of which, not only the power of the screw was prodigiously increased, but the platten was made to descend quickly, and with little power at first, and only exerted its enormous force just as it reached the form. The immense advantage thus given, not only to the pressman, but by the improvement of the work produced, and the simplicity of the lever-head, presently induced an application of the new principle to the old presses. It was, however, soon found, that the wooden press was not calculated to sustain the operation of this compound power, especially when applied, as it was, in several instances, without any accurate calculation of its probable effects: and hence the framework of the altered presses constantly gave way, and repeated repairs were rendered necessary. This violent experiment made upon the old machines contributed, along with the obvious superiority of the new ones, to the prompt and general substitution of iron presses for those of wood.

Johnson, in his "TYPOGRAPHIA," has figured, and very minutely described, the iron presses in greatest estimation; viz., the *Stanhopian*, the *Columbian*, and the *Albion*. From the very instructive and curious work just named, the author of which was not only an ingenious writer, but an admirable practical printer, most of what follows on the subject of these presses is derived. The annexed cut (*fig.* 65.) represents the Stanhope press

Fig. 65.

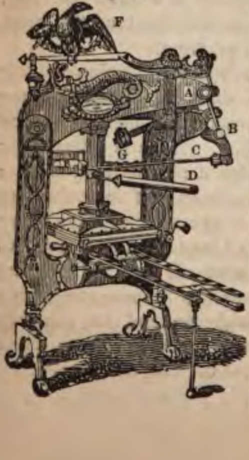


A is the upright body of the press, called the staple. B, the bottom piece, called, from its figure, the T. Parallel with this piece, and supported by C, the standard or forestay, are two grooved rods, called the ribs, along which the table D slides, so as to carry it under the platten to receive the impression, or to admit of its being thrown out as represented in the figure, in order to have the sheet placed upon or taken off the surface of the types. E, a stout lever-head, eight inches in length, fixed upon an upright arbor, to the lower part of which the bar handle F is fastened. G, a stout lever-head, ten inches in length, fitted upon the main screw, and connected with E by a coupling bar, bolted at both ends with steel cottars. H, the platten, in length twenty-six inches; in width twenty inches. It is attached to the lower end of the main screw, with the motion of which it rises and falls: the platten is raised, and the handle drawn back after each pull, by means of the weight I, suspended to a forked lever or balance iron. The table D, already mentioned, and upon which the types are placed, is twenty-nine inches long and twenty-four inches wide; having upon hinges at its extreme end a light frame, K, upon which a piece of vellum, called the tympan, is tightly stretched. To the end of this frame, again, is hinged another, L, called the frisket, having strings across, to assist in keeping the paper against the tympan during the turning down of the latter, and likewise to lift the paper from the types, to which it sometimes adheres pretty closely after the impression has been taken. It may be proper to mention, that these strings pass along the spaces left between the pages of type, and consequently bear only upon that part of the sheet which remains blank after the printing.

Iron presses are indebted for no small portion of their great superiority over the wooden ones, to the extreme accuracy with which the corresponding surfaces of the platten and the table are levelled. This is effected by turning them at the lathe, with a sliding rest, with a degree of precision that may be judged of from the fact that, when properly finished, they are expected in every part to bite a hair or a piece of paper. The wonderful precision with which these surfaces act in bringing away, from an area of types equal to the size of one side of a large newspaper, every single line and dot, can only fail to astonish those who, from ignorance alone, think nothing difficult.

The Stanhope press, as already stated, is the invention of the late patriotic nobleman whose name it bears; who, after many expensive and laborious experiments, at length succeeded, with the assistance of an ingenious machinist (the late Mr. Walker), in bringing the press to a state of perfection. The first press was finished in the year 1800; and its powers were tried at the office of Mr. Bulmer, the Shakspeare press. They have since undergone several alterations, particularly in the rounce and the ribs. The handle of the former was attached to a rod which crossed the platten; this rod was connected with the spit by means of machinery; the carriage, instead of running on cramps in the ribs, as at present, was carried upon wheels on a straight edge, which made a very disagreeable noise; the gallows for the tympans is also removed, and the bearings are attached to the ends of them. At first, the presses were very apt to break in one part or the other, particularly in the staple, which at length was discovered to have been cast too weak to bear the extraordinary power applied: this evil was afterwards remedied, by casting them considerably shorter; since which they have maintained their character for being excellently well adapted for the purposes of printing, as well as being durable, and not likely to get out of repair, provided they are kept clean and well oiled, which are most essential requisites, not only for this, but for all kinds of machinery. His lordship having objected to the taking out of a patent for his invention, it was consequently thrown open; upon which [illegible] engineers and smiths [illegible] to manufacture presses on [illegible] same principle.

Fig. 66.



The opposite cut (*fig.* 66.) represents the Columbian press, so called by the inventor, Mr. George Clymer, of Philadelphia, in America. It was first introduced to the printers of Europe in 1817, and since that period it has become an almost universal favourite in this country; being superior in power to every other press in use, and not inferior to any in management and promise of durability.

These presses have been in constant use, for nearly twelve years, in the royal printing-offices; in those of the universities of Oxford and Cambridge; in the royal printing-offices of the emperor of Russia and the king of Holland; in America; in the East Indies; and in more than four hundred of the most respectable printing-houses in London, Edinburgh, Glasgow, and, in short, in most of the important towns in England, Scotland, and Ireland. Mr. Johnson thus speaks of this truly ingenious machine:— "The highly favourable and very flattering testimonials which Mr. Clymer produced on his arrival in London, from the gentlemen connected with the press in different parts of the United States, where they had been in active operation, clearly evinced to the printers of Great Britain and Europe that his invention was well deserving their countenance and encouragement; and, notwithstanding they had presses not only of the Stanhopean manufacture, but also of several others, yet the properties of Clymer's Columbian press, supported by the above testimonials, were the immediate cause of their introduction into several of the first houses of the metropolis, and many of the others soon followed."

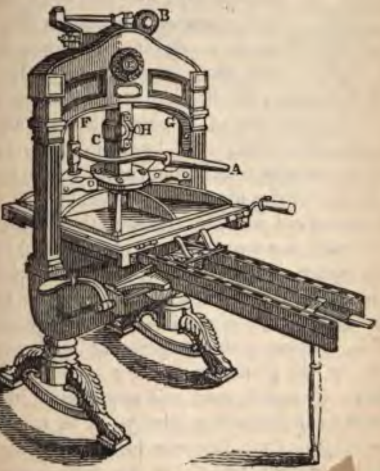
Mr. Johnson then gives the following instance of the powerful application of the Columbian press, in printing an elaborate engraving on wood, executed by Mr. William Harvey, from a painting by Haydon,—the subject, the Assassination of L. S. Dentatus. It had been found extremely difficult to get even a proof impression from the block by means of the Stanhopean; "nor do we believe," says the printer, "that any other press in use at that period (1821) would have been capable of giving the power required (the Columbian excepted), even with additional leverage. In truth, however powerful, and extraordinary the force of the impression given, when contrasted with other presses; and many of our brethren (in their recommendatory letters to Mr. Clymer) have represented it as being capable of printing the largest form with the greatest ease, *even by boys;* in this instance we found it insufficient.

"We shall now briefly explain the operation of printing the above-mentioned extensive and most curious wood engraving. The size of the subject was fifteen inches by eleven and a half, which was composed of seven pieces of wood, through which passed four strong iron bolts with nuts at each end to draw the wood close together as it shrunk; but even this did not prevent it, particularly in dry weather; and although the nuts were drawn up as tight as possible, still they would not force the wood close on the face, notwithstanding it was full up at the bottom. Consequently, we were obliged to take the bolts out and alter it, before we could proceed with the printing. This being done, we next found that even the Columbian press, of the extraordinary power of which so much had been said, was not sufficient for this block; consequently we had a new *bar* made, considerably longer than usual, which was so bent, that it just left sufficient room for the tympans to rise and fall; otherwise it went so far over that a man could not reach it. Even this had not the desired effect; so we next resolved upon having about two inches taken off the connecting-rod, which enabled us to accomplish our object with respect to the impression; but, notwithstanding we had thus increased the power, we found it necessary to have two stout men, instead of one boy, as stated by many of our brethren, who little thought, when making such an assertion, that so extraordinary a power would ever be required for printing work of any description at so powerful a machine as the Columbian press." The writer proceeds: — "We are free to confess, that the very extraordinary power applied to the Columbian greatly exceeded our most sanguine expectation, and astonished every beholder, — even Mr. Clymer himself, who declared that the press was never intended to have such a power: but we are proud to state the engraving was printed without the least accident; and we can boldly assert, that no press can possibly produce better work than the Columbian; yet we do not consider them so well adapted for light jobs as they are for heavier work; neither are they so expeditious as some others: the bar is too far from the hand; and, from the quantity of levers, the bar can never come down or return so quick as where the power is gained by a simple motion."

It will not be necessary to describe in detail all the parts of the Columbian press, as it must be apparent, on inspection, that, although somewhat more expanded and ornamented in its substantial parts, it differs from the Stanhopean chiefly in the principle upon which the power is communicated. In the press now under consideration, the main screw is dispensed with altogether; instead of which, the inclined piece A (*fig.* 66.) is a massy cast-iron lever working in a joint at the top of the near cheek of the machine, and having near the middle a joint, to which a square piston, working between two guides, and supporting the platten, is bolted: to this inclined piece is attached, by means of two short parallel bars, the short bent lever B, likewise moving by a joint at the upper end of the farther cheek, which for this purpose is bent outwards. To the last mentioned lever is joined, by means of the connecting rod C, the working handle D, the end of which at E again operates as a lever of the most powerful order. Since the work by Mr. Johnson, alluded to before, was published, some improvements have been adopted in the manufacture of this admirable press; especially the removing of the working bar from the far to the near cheek, as it appears in the engraving from a figure kindly furnished by the manufacturers, Messrs. Clymer and Dixon; so that the complaint of its being too far from the hand is now obviated. At present, therefore, this press works, in all probability, as quick, if not quicker, than any other, requiring only a short, or what the pressman calls a three quarters, pull: hence, as the writer of this notice has had abundant opportunities of observing, it is adapted to print with expedition and success any form, from a small card to a double-royal sheet. F is an ornament intended to act upon the balance-lever, which, assisted by the weight G, pulls back the handle after the impression has been effected.

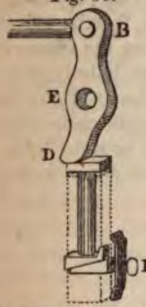
Another press, which ranked high in the estimation of printers, was the Albion, invented by Mr. R. W. Cope; and, according to the ingenious author of "Typographia," above quoted, this machine is entitled "to a place in the front rank in the list of presses, and that in every point of view: — first, they are much lighter in respect to weight of metal: secondly, the pull is very easy; notwithstanding which, it is equal in power to any of them, not even excepting the Columbian, of the extraordinary power of which so many high encomiums have been passed by the principal printers of Europe and the United States: thirdly, it is better adapted for expedition, because the bar is attached to the near cheek, and not the far off one, as (was formerly the case) in the Columbian: fourthly, there are so few parts belonging to it, and consequently the machinery is in itself so simple, that there is not the least chance of their being put out of order, or liable to the least accident from wear: fifthly, the works, being so simple, are all contained in the hollow of the piston, on which the power is given; (this is the first instance of a hollow piston ever having been used for a press): sixthly, the bar passes over the platten, just sufficiently to clear the rise of the tympans; consequently the bar-handle is soon in the hand, and as soon out again, from the short evolution which the bar has to traverse, it not being more than one fourth of a circle; therefore considerable despatch is given, as must be self-evident to every one who gives the subject the least consideration. Of course we anticipate no objection to this opinion from those who are acquainted with the mechanism of presses." It would not be easy to describe in detail the mechanism of the Albion press, without at the same time giving detached figures of the smaller parts. It has, however, no screw: the bar-handle acting by means of a connecting rod, upon a fulcrum or mouth-piece of solid iron, the top of which works against a trunnion under the middle of the press head: in the centre of this fulcrum are two projecting lugs, one on each side. These lugs are for the lower part of two stout links to work upon, when the impression is given. The Albion, however, has latterly been superseded by the Imperial press of Messrs. Sherwin and Cope. In this beautiful and compact machine, the works upon which the power depends are almost wholly concealed within the head of the press, and are in them-

Fig. 67.



selves extremely few and simple. *Fig* represents the Imperial press, which, in its gen cture, resembles the Albion. The leverage connected with the bar-handle A is similar in principle to that of the Stanhope press; and the distinguishing peculiarity of the press now under consideration consists in the manner in which the piece B is made to act upon the piston C. This will be easily understood by an inspection of the cut in the margin (*fig.* 68.), the letters of reference in which agree with those in the figure of the press itself. B is a projecting head of the stout cast-iron lever, which terminates in a sort of polished toe or point, D. This last-mentioned projection of the lever is made to act upon the head of a stout iron bolt, which simply drops down a perforation of the piston, so as to rest upon the uppermost of two steel wedges, one of which, by its connection with the screw H, admits of being pushed forward or drawn back, so as to elevate or lower the bolt, and thus regulate, by altering the length of the piston, the bearing of the platten upon the types. The head-bolt at E passes through a hole perforated somewhat obliquely; by which ingenious contrivance, a side twist, which would otherwise be occasioned by the motion of the head gear, is avoided. It will now easily be perceived how, by the operation of the handle, the toe is made to act upon the inside bolt, and thus force down the piston, which, after the impression has been taken, is carried back again, by means of two stout steel springs attached to the insides of the cheeks of the press, FG. These springs, operating uniformly, cause the action of the piston to be very smooth. The Imperial press, for speed, ease, and evenness of impression, has obtained considerable celebrity: it is manufactured at prices varying from fourteen to eighty guineas; the size of the platten being for the former terms nine inches by thirteen, and for the latter twenty-four by forty inches.

Fig. 68.



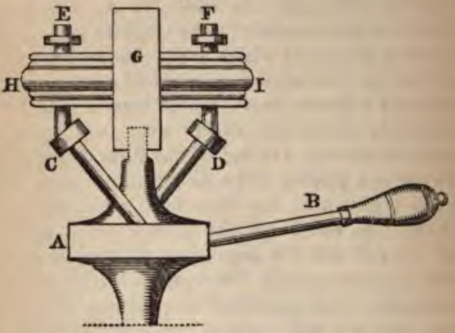
Having thus briefly described the iron presses which have obtained most celebrity among respectable printers, it may be proper to notice, as compendiously as possible, some contrivances of less note; and afterwards those more complex and curious machines which have been introduced within the last twenty years; and in which the inventors, by substituting for the reciprocating action of the screw and the lever a continued rotatory motion, have brought into their aid the fly-wheel and the steam-engine, working these uniform powers with a precision and celerity which could hardly have entered even into the dreams of a printer half a century ago.

Ruthven's patent press, which was at one time in considerable estimation, differs materially from those already described. Instead of the form of types being rolled under a platten, and back again, when the impression has been made, the type form remains stationary upon the iron table, and the platten and tympans are drawn over it, and the impression effected by means of a lever worked vertically like a pump-handle, and acting by connecting bars upon both sides of the platten, so as to draw it down with the requisite ease and effect.

A few years ago, a new press was constructed by Mr. Medhurst, of London, the great recommendation of which was its simplicity, and consequent cheapness. In its general form it much resembled the iron presses in common use, the principal difference being in the manner in which the pressure was produced. This was accomplished by means of an ingenious arrangement of levers, differing so much from every thing previously employed in machinery, that the inventor described his contrivance as one which exhibited a new power in mechanics.

The principle upon which this press acts will be understood from the annexed sketch of the parts by means of which the impression is given. Instead of a screw, a plain spindle is employed: on the lower part of this spindle there is a swell or collar, A, into which the handle, or working bar of the press, B, is fastened. The upper part of this collar has cups or steps for the reception of two short iron props or pins, C, D, which extend up to the head of the press, and are there supported by the points of two screws, E, F, entering sockets cut out in the heads of the pins, which are made of steel. When the platten is up, these pins stand in an inclined position, as represented in *fig.* 69.: but when the lever handle is pulled towards the spectator, so as to turn the spindle, the two screws remain stationary, while the props come into a vertical position, thus forcing the spindle and attached platten to descend, as if a screw were employed. It may be observed that, in the figure, G is merely a section of the head of the press, which is supposed to be looked at sidewise, to present the back and front projections H, I, through which the screws pass. In the presses invented by De la Heine, a plain spindle was used; and, instead of the common screw, a cross arm, fixed to the upper part of the spindle, was made to traverse a sort of circular inclined plane — in fact, a section of an irregular screw; and by this means the platten was made to descend with the requisite force. Presses on this principle, and with the Stanhope levers, have not been uncommon. Various others might be mentioned; but it is necessary to take

Fig. 69.



some notice of the more complex printing machines which are now so largely manufactured.

So early as the year 1790, Mr. W. Nicholson obtained a patent for a machine for printing on paper and other substances by a more neat, cheap, and accurate method than by the presses at that time in use. His plan was, to cast the letters, &c. tapering on the shank, or, in other words, as the segments of a circle agreeing with the periphery of a roller, upon the surface of which these types were to be firmly imposed in the same manner as common letters are imposed upon a flat stone. He likewise applied the ink, or other colouring matters, to his types by means of stuffed rollers or cylindrical brushes. On these accounts, he is considered by some persons to deserve the credit of having first suggested the idea of that system of machine printing now under notice,—but surely with very little reason, all things considered, except, indeed, so far as respects the inking rollers.

The honour of first having so far carried out the idea of a steam printing machine, as to deserve the appellation of its inventor, belongs to another individual, a native of Saxony, named König, who was assisted by his countryman Bauer. These two ingenious individuals, supported by the munificence of some persons concerned in the printing business in London, succeeded, after long trial, the purchase of successive patents, and some of the usual mortifications of theorists, in bringing to perfection a very large, expensive, and complete apparatus. "At length," says Johnson, "this machine, which had been made in obscurity, was brought forth (in 1813-14) to astonish the world by its wonderful action, in receiving and delivering an almost incredible number of sheets per hour. The place selected for this experiment was the office of *The Times* newspaper, when the very extraordinary impression that is daily taken of this journal was struck off in a very short space of time, compared with what would have been necessary by manual labour at the presses, which required such great exertion that the stoutest constitutions fell a sacrifice to it in a few years, yet others were eager to fill their stations; therefore this could not be assigned as an excuse for their (the machines) introduction."

The machine thus successfully set up was followed by others manufactured to order for various eminent printers in the metropolis. This course, and the concomitant practice of stereotyping popular or standard works, so alarmed the journeymen, that they set themselves against what they considered so inimical to the welfare of the trade; and, for a time, compositors and pressmen, countenanced by some of the master-printers, refused to work for those houses who had so daringly innovated on the old system. These feuds, which are now happily forgotten, are alluded to, in the work already quoted, in a manner which cannot fail to excite surprise that a really ingenious mind could be so warped by prejudice, and so blinded by a false view of self-interest.

The flail-user may complain of the threshing-machine, and the sailmaker of the steam ship, because these latter inventions are, as it were, but the recent invasions of science upon the primitive modes of beating out corn and appointing vessels in this country; but the printing press in its rudest form was a machine substituted for manual labour, at a time when it was infinitely less easy than at present for a race of ingenious and even literate men to find their subsistence by a new employment: with how much reason the scriveners of the fifteenth century would deprecate the use of the new-fangled printing press we may easily conceive. It would be strange indeed, if the press, to the justly boasted liberty of which we are indebted so largely in all our scientific improvements, were to set itself exclusively against the enlargement of its own immense capabilities. Whatever cheapens knowledge deserves our applause, certainly not less than that which merely beautifies its exhibition. If literary and intellectual excellence had been at all conservated by the use of hand presses alone, or even had fine printing vanished on the introduction of machines, then there would have been good ground for the complaint above quoted. The reverse, however, of both these issues has literally taken place. How different from the querulous apprehensions of Mr. Johnson are the sentiments of the excellent and learned Dr. Olinthus Gregory, in a lecture delivered by him before the Mechanics' Institution at Deptford, in 1826. Among other topics illustrative of the patronage afforded to the arts and sciences by the intelligence and enterprise of this country, the venerable lecturer directed the attention of his audience to "the case of Mr. König, a truly ingenious foreigner, and his invention of an improved printing press, in which, by duly blending the alternating and rotatory principles of motion, the apparatus is capable of working off 1100 sheets in an hour, with the superintendence of two boys. Tracing the history of his invention, of his difficulties, and of his want of encouragement, through the greater part of the continent of Europe, Mr. König says, 'I need hardly add, that scarcely ever was an invention brought to maturity under such circumstances. The well known fact, that almost every invention seeks, as it were, refuge in England, and is there brought to perfection, seems to indicate that the Continent has yet to learn from her the best manner of encouraging the mechanical arts. I had my full share in the ordinary disappointments of continental projectors; and, after having spent in Germany and Russia upwards of two years in fruitless applications, I proceeded to England.'

"What could not be accomplished by the encouragement of princes on the Continent," proceeds Dr. Gregory, "was effected by the aid of private individuals in London. A few enterprising printers,— and their names cannot be mentioned but with honour on such an occasion; Mr. Thomas Bensley, Mr. George Woodfall, and Mr. Richard Taylor,—liberally assisted this ingenious foreigner in bringing his invention to maturity. The machine was set to work in April, 1811, and 3000 copies of sheet H of the 'New Annual Register for 1810,' were printed by means of it. This was, doubtless, the first part of a book ever printed solely by a machine.

Messrs. Bacon and Donkin were, it is true, simultaneously at work upon analogous contrivances; and, since then, other ingenious artists, especially Applegath and Cowper, have contributed greatly to the simplification of this class of machinery."

In the earliest attempt to substitute rollers for vertical pressure in type printing, the most plausible idea as to practicability was, as we have already seen, suggested by Mr. Nicholson, namely, the making of the types to stand together in the segment of a circle on the surface of a cylinder, like the stones which form an arch. With loose types, as must be at once apparent, this ingenious scheme was in reality impracticable. It led, however, to the curving of stereotype plates for the purpose of fixing them on a cylinder, for which, in 1815, Mr. Cowper obtained a patent. Machines constructed in this way were found capable of printing 1000 sheets per hour on both sides, and twelve of them were at one time made for the use of the Bank of England. The final improvement, however, resulted from the invention of König already mentioned, and which consisted in taking the impression, by means of rollers, from the table or form of types lying in a horizontal position, as in the common press.

The perspective view (*fig.* 70.) of what has long been known as Applegath and Cowper's machine, here presented to the reader, is derived from an engraving prefixed to the substance of a lecture on the recent improvements in printing, delivered by Mr. Edward Cowper, at the Royal Institution, February 22. 1828. This interesting memoir exhibits succinctly the steps by which the machine was brought to its present state of perfection, and, at the same time, presents a candid review of the exertions and success of other inventors having the same object. Before we proceed to describe the engraving, it may be interesting to remark, on the authority of this document, that Applegath and Cowper have constructed upwards of seventy of these expensive machines upon their combined patents, modified in twenty-five different ways, for the various purposes of printing books, newspapers, bank notes, &c. Some idea of the simplification in the structure of the apparatus now in use, may be

Fig. 70.

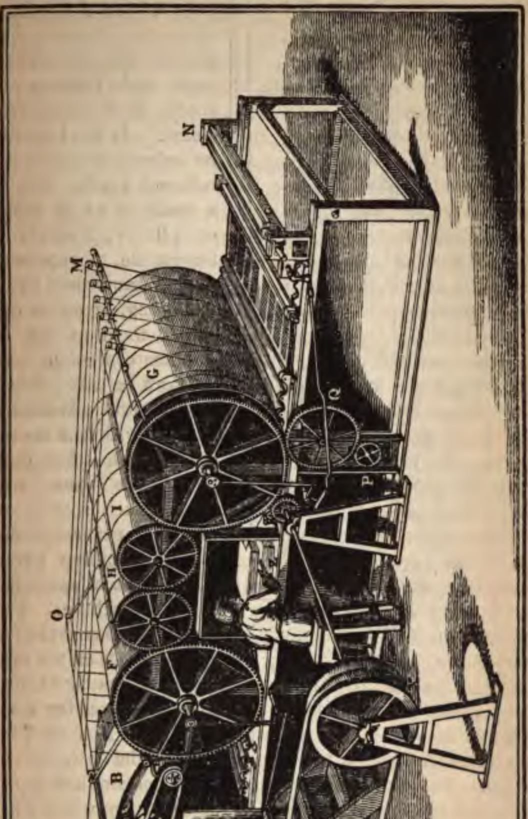
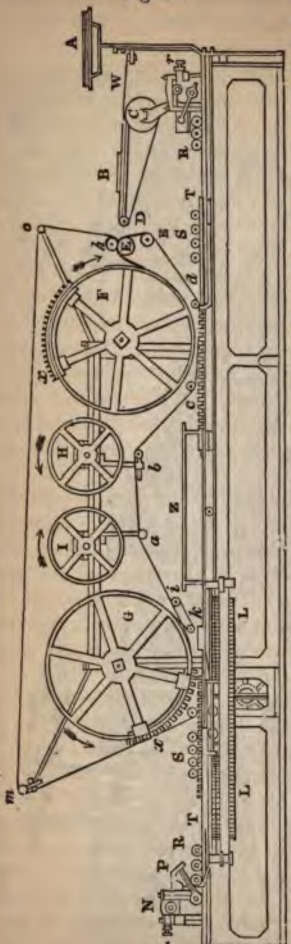


Fig. 71.

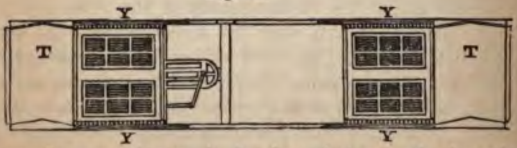


formed from the fact, that not fewer than forty wheels were removed from König's machine, when Mr. Bensley employed Messrs. Applegath and Cowper to apply their improvements. It need hardly be intimated to the intelligent reader, that in a machine of so much complexity, it would be impossible to represent every minute part in an engraving, or so to describe them as not to produce confusion. All that can be done, therefore, with advantage, will be, with the assistance of the foregoing perspective view, and the annexed section, to describe generally the more prominent parts, and the actual operation of the machine. The section is taken from the opposite side of the machine to that exhibited in the perspective delineation. A (*fig.* 71.) shows the supply of blank paper, laid upon a table, from whence the sheets are drawn, one by one, by the boy standing upon the platform, and who lays them out upon another table, B, across the surface of which runs a number of narrow linen tapes. These tapes are formed into endless bands, which extend round the cylinders or rollers C and D (*fig.* 71.), in such a manner, that when the rollers revolve, the motion of the tapes carry the sheet of paper with them, and deliver it over another roller, E, where it is taken up by two sets of endless tapes, passing over a series of rollers to keep them extended. These tapes are so adapted in number and position, as to fall between the pages of printing, and also to pass along those portions that become the margin of the printed sheet. They, therefore, remain in contact with both sides of the sheet of paper during its passage through the machine. By this means the paper, being once received between these systems of endless tapes, continues its course along with them, in order to bring it into a situation to be printed on both sides, without destroying what is technically called the register, or coincidence of the pages on opposite sides of the sheet.

In the longitudinal section, F and G represent the two main cylinders, which effect the pressure upon the paper: they are mounted upon strong axles, which turn in stationary bearings affixed to the frame of the machine. H and I are two intermediate cylinders, the use of which is to effect the inversion of the sheet of paper during its passage from one of the main cylinders to the other, in order to print the opposite side.

To return to the endless tapes: suppose the system of them to commence at the upper part of the roller E (*fig.* 71.), from whence they proceed in contact with the under portion of the circumference of the main cylinder F: they then pass over the upper part of the intermediate cylinder H, and under the intermediate cylinder I, from whence they proceed to encompass a considerable portion of the main cylinder G; and, by passing in contact with the small rollers *a*, *b*, *c*, and *d*, they arrive again at the roller E, from whence they commenced, thereby forming one of the systems of endless tapes. The other system may be supposed to commence at the roller *h*; they are equal in their number to the tapes already described, and correspond also with them in their place upon the cylinders, so that the sheets of paper may be securely held between them. This second series of tapes descend from the roller *h* to the adjacent roller E, where they meet and coincide with the first system, in such a manner that the tapes proceed together under the main cylinder F, over the intermediate cylinder H, and round the other main cylinder G, until they arrive at the roller *i*, where they separate: having remained thus far in actual contact, except at the places where the sheets of paper are held between them. From the roller *i*, the tapes descend to the roller *k*, and by passing in contact with the rollers *m o*, the tapes arrive at the roller *h*, from whence they commenced. Thus the two systems of tapes pursue, undeviating, their appointed courses, without interfering with each other. In the perspective view (*fig.* 70.) it will be seen, that the cylinders F, G, H, and I (and also the roller marked E in the section) are connected by cog-wheels, so as to cause their surfaces to move with steady and uniform velocity, and thereby prevent any sliding or shifting of the tapes over each other during their motion, as much of the perfection of the printing depends upon this circumstance. The separate forms, or enclosures of types, consisting say of twenty four pages, and designed to print both sides of the sheet, are placed at a certain distance asunder, upon one long bed or carriage (*fig.* 72.). This carriage, with the forms of types

Fig. 72.



properly secured upon it, is adapted to move backwards and forwards upon steady guides or journeys, attached to the main frame of the machine, in such a position that the surfaces of the types may be operated upon by the circumference of their respective cylinders, F and G, to produce the impression, as the carriage moves backwards and forwards. This reciprocating movement of the carriage is effected by a pinion fixed upon the end of a vertical spindle, taking into the teeth of an endless rack, L L, which is connected by a system of levers with the type carriage in such a manner, that when the pinion is turned round, it engages, at alternate periods, in the teeth formed on the opposite sides of the rack, and consequently on the opposite circumference of the pinion; thereby a continuous motion of the pinion communicates a reciprocating motion to the rack and carriage. The vertical spindle is turned by a couple of bevelled wheels, from the pinion P (*fig.* 70.), which receives its motion by an intermediate wheel Q, from the toothed wheel upon the end of the main cylinder G.

We shall now describe the mechanism for supplying and distributing the ink upon the surface of the types, previously to each impression being taken. Mr. Cowper says, "The hand inking roller and distributing table, now so common in every printing-office in Europe and America, is my invention, and is included in my patent. The decided superiority of the inking apparatus in our machine over the balls used at the press induced us immediately to apply it to the common press, and with complete success. The invention, however, was immediately infringed throughout the kingdom; and it would have been as fruitless to have attempted to stop the infringement of the patent as it was found in the case of the kaleidoscope." It will hardly be conceived,—what was nevertheless the fact,—that to distribute aright the ink was one of the most difficult points of attainment in the construction of printing machines. In the admirable machine now under our notice, this desideratum has been most successfully effected by the ingenuity of Mr. Cowper. The apparatus for inking consists of two similar and complete systems; one situated at each end of the machine, so as to be adapted for inking their respective forms of types. At N, right hand of *fig.* 70., and opposite end of *fig.* 71., is a cylindrical metal roller, which has a slow rotary motion, communicated to it by a catgut band passing round a small pulley upon the end of the axis of the main cylinder G. The roller N is adapted to carry down a thin film of ink upon its circumference, by turning in contact with a mass of ink disposed upon a horizontal plate of metal; the edge of which plate is ground straight, and fixed by screws disposed at small distances in the line of *r*, so as to adjust the distance between the two surfaces. Upon an axis turning at P is mounted a composition roller, connected by cranked levers with a small eccentric circle fixed upon the end of the axis of the cylinder G, causing it to move round the axis P, and remain for a short period in contact with the face of the ink roller N, thereby receiving a portion of ink upon its surface: it then descends, and rests with its whole weight upon the surface of the table T, which is affixed to the end of the type carriage, as represented in *fig.* 72.; so that the reciprocating motion of the carriage causes the ink table T to receive ink upon its surface from the elastic roller before mentioned. In this situation, when the type carriage returns, the surface of the table T is made to pass under three elastic rollers, indicated at R: these rollers are mounted upon pivots, in a frame, in such a manner that they have liberty to move somewhat up and down, in order that the rollers themselves may bear severally upon the surface of the table.

Further to provide for the full and equal effect of these rollers, the frame in which they are placed has a slight end motion given to it by the inclined form of the end of the table, as seen at T T (*fig.* 72.), bearing against a roller fixed upon the said frame. Thus the small composition rollers R operate in a very complete manner to equalise the supply of ink over the surface of the table; and, by the further motion of the type carriage, the ink table is caused to pass under four other small elastic rollers, S S, which in like manner bear with their weight upon the surface of the table, and thereby take up the ink upon their circumferences, which they impart to the types as the form travels backwards and forwards under them, thus touching every type eight times.

Whilst the operation of inking the types is going on at one end of the machine, the printing is performed at the other end on one of the sides of the sheet from the types last inked; and *vice versâ.* The type carriage is caused to move steadily along, with the circumferences of the cylinders F and G, by means of racks Y Y, placed alongside each form of types, and which racks engage with sectors or portions of toothed wheels, *x x*, upon the ends of the aforesaid cylinders; at which part the surfaces of the cylinders are covered with a blanket, or with felt, to give elasticity, and cause them to press equally upon the paper, as in ordinary printing presses.

Motion is given to the whole machine by a fly wheel and handle, or by a strap coming from a drum of the steam engine, and passing round the pulley X, upon the axis of which a pinion is fixed, engaging with the teeth of the large wheel upon the end of the main cylinder G. The four cylinders respectively revolve with an uniform motion in the direction of the arrows in *fig.* 71.

Having thus described the principal parts of the machine, its operation will be still better understood by the following description of the method of taking an impression: — The sheets of blank paper are, as already stated, transferred one by one, by a boy, from the heap A to the table B (*fig.* 70.), so as to bear upon the linen tapes which extend over its surface. In this situation, the rollers C and D are made to move a portion of a revolution by the operation of a lever fixed upon the axis of the roller D, being acted upon by another lever fixed on the cog-wheel of the main cylinder F. This motion advances the sheet of paper sufficiently to allow of its being seized between the two systems of endless tapes, at the point where they meet each other, or between the rollers *h* and E. As soon as the sheet of paper is carried clear off the table B, the rollers C and D are caused to turn back again to their original position by the operation of a weight attached to the cord W, ready to advance a second sheet of blank paper into the machine. The sheet of paper is carried along between the system of tapes, and applies itself to the circumference of the main cylinder F, upon the blanket before mentioned; and by the continuous motion of the cylinder the sheet of paper is pressed upon the surface of the form of types, as it passes under the cylinder, by the reciprocating motion of the carriage.

By this means one of the sides of the sheet receives its impression at the same time that the form of types situated at the opposite end of the carriage, is receiving the ink, as before described. Now, by the continuous motion of the machine, the sheet of paper advances in company with the endless tapes round the intermediate cylinders H and I, until it applies itself to the blanket upon the surface of the main cylinder G; at which place it will be found in an inverted position; so that the printed side of the sheet is in contact with the blanket, and the blank side of the sheet downwards, which, upon meeting with the other form of types at the proper instant, is pressed upon its surface with a sufficient degree of force to produce the impression. Thus having arrived at the point *i*, where the two systems of tapes separate, the sheet printed on both sides is delivered upon the board Z, in the open space under the machine, where it is received by a second boy, and laid upon the pile.

Such were the improvements in the art of printing effected mainly by the genius of Mr. Edward Cowper, assisted by his partner and relative, Mr. Augustus Applegath. Great, however, as was the speed with which the work was executed by this means, it did not equal the exigencies of the daily press of London. "The Times" newspaper, in particular, felt the impossibility of meeting the demands of its large circulation between the rising of the houses of parliament at a late hour in the morning, or the arrival of foreign despatches, and the hour at which it was necessary to deliver the paper to the venders. It became, therefore, a matter of the last importance for that journal to obtain the means of printing so large a number as 10,000 or 12,000 in the short interval of the morning to which we have just alluded.

A very simple modification of Cowper and Applegath's machine, just described, accomplished this, and performed, indeed, what may be almost regarded a miracle of art. Mr. Cowper, considering that the speed of execution in the machine already constructed, was limited, not by the want of capability of speed in the machine itself, but by the rate at which it was possible for the boy, called the feeder, at A (*fig.* 71.), to supply the paper, suggested that the machine should be constructed so as to multiply the number of feeders, by placing on an elevated stage a feeder at each end of the machine, and two feeders below, so that four sheets were always passing through the machine at the same moment. Mr. Applegath suggested that the four printing cylinders should be of small diameter, and be made to rise and fall in order that they might be brought near to one another, and thus diminish the distance the form would have to travel. On these combined suggestions, the machine by which "The Times" newspaper is now printed (1842), was planned and constructed by Mr. Applegath. That paper is now printed, daily, at the rate of 4200 sheets per hour, on one side; on one emergency, 5000 were printed in the hour.* At the present time (1853) two vertical cylinder machines in "The Times" Office are producing each 10,000 sheets per hour.

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* The matter contained on the other side of the sheet is usually printed the preceding day or the evening before. This may be always accomplished, since a sufficient portion of the matter is always supplied before the preceding night.

In "The Times" of February 14. 1828, appeared the following paragraph: — "It is now nearly fourteen years since 'The Times' first issued from our office printed by steam and a mechanical apparatus. At that time we spoke, as we thought, with becoming praise of the perseverance and ingenuity of the inventor, Mr. König, and with sufficient modesty, we trust, of our own firmness and resolution in overcoming opposing difficulties, and even dangers. This surprising machine has since received certain improvements from the hand of its original inventor; but we have now to present to our readers and the public an account of a vast and a most beneficial change which has taken place. The first machine printed but 1100 sheets per hour—the reader now holds in his hand an impression which a new machine has yielded at the rate of *four thousand an hour!* Such ease, rapidity, and accuracy united, could hardly ever before be ascribed to any fabric constructed by the hand of man. Let but the reader contemplate, if he can, what must be the rapidity of those motions which throw off four thousand printed sheets in every hour, or nearly seventy in a minute!"

This rate of printing has been greatly exceeded by the introduction of a machine with vertical cylinders.

The chief advantage of this new arrangement is, that the whole motion or circuit of the type can be made available for printing, whereas, in the flat machine, more than half the motion of the reciprocating type-table is lost: and the reason for placing the cylinder in a vertical position is to obtain more easy access to the type, inking rollers, and other parts of the machine, and to permit more impressing cylinders to be arranged around the type-drum than can be done when it is fixed horizontally.

The circumference of the central drum, or path of the type, is exactly 200 inches; in the machines at "The

Times" Office, eight impressing cylinders surround the type, which therefore print eight sheets at every revolution; but in those machines the type is not truly cylindric, but is segmental, which involves the necessity of using large cylinders, but when the type is purely cylindric smaller impression rollers may be used, and the produce very much increased.

A machine of this kind was erected in the Great Exhibition, where it excited much attention; it printed circular woodcuts and type in the best manner. Each of the four impressing cylinders has fifty inches space for itself and its attendant inking rollers, and the form has the advantage of receiving its ink or colour from several rollers, each of which is well distributed, or evenly covered with ink.

The vertical position of the inking rollers also conduces greatly to the production of good work; for the type or engraving is only touched on its extreme surface, while, on the flat principle, where the inking rollers act by gravity, the side of the type are liable to receive colour. Another advantage is, that any dust in the paper is shaken out by the act of stopping, and falls upon the floor in place of being deposited upon the inking rollers and distributing table as in the flat machine: this is in practice a real advantage, for 50,000 impressions have been taken without once stopping to brush out the form or table. Another technical advantage in the printing of wood engravings, where delicate overlaying is required, is that the impressing cylinders are in direct connection with the type-drum, so that no irregularity of motion can occur, and the overlays can be placed precisely where required without any fear of derangement.

Attention is also directed to the superior smoothness of the action of the vertical machine, as compared with the heavy blows produced in a flat or reciprocating machine at each change of motion in the ponderous type-table and its appendages.

The action of the machine is very simple: the "layer on" draws a sheet of paper towards a small roller in rapid motion, which descends and causes the paper to enter between the vertical tapes which carry it downwards, when, having arrived at the proper position it is suddenly stopped by narrow upright strips of wood, which advance and slightly compress the sheet between them, the vertical tapes at the same moment releasing it; the stoppers are then in their turn withdrawn, leaving the sheet of paper momentarily suspended by two small pulleys, mounted on delicate springs called finger rollers. The sets of vertical rollers on each side of the sheet now advance against it, and impel it sideways towards the impressing cylinder, where it receives the impression from the type; the sheet continues its side motion, supported only by a single pair of tapes, which at the proper place are stopped, leaving the printed sheet suspended until the "taker-off" draws it down upon the taking-off table.

The chases which hold the type are made with circular beds, and are securely fixed to the iron rings of the type drum. The column rules are converted by means of screws into tension bars, and they bind the sides of the chase or type holder together, so that each column can be set up by means of a screw at its foot to any required degree of pressure. The inking rollers in their vertical position between the impressing cylinders, are caused to press against the type and distributing table by long coiled springs adjusted to a proper tension; they receive the ink from a circular distributing surface placed opposite to the type, and which during its revolution rises up and down by travelling upon an undulating railway. The ink is deposited upon the distributing table by a roller which occasionally vibrates against the ductor roller of the ink box.

The wheels which connect the type drum and the impressing cylinders are beneath the machine; motion is communicated to the ink box by a level wheel on the spindle of the type drum, and to the feeder by a lower bevil wheel.

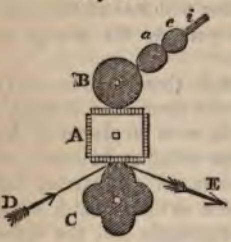
The vertical principle admits of great variety of construction, and is equally applicable to machines for book work.

Cowper's invention of the hand roller has effected a complete revolution in the art of printing. In any book printed previous to this invention, a great inequality is discernible in the colour of the page, some parts appearing dark and others light, some letters smothered with ink, and others not half covered; this inequality has now totally disappeared. The standard quality is so much raised, that work, which would have been considered unobjectionable fourteen years ago, would now not be tolerated. Any one who compares an early volume of the Edinburgh Review with one of the more recent numbers, will at once perceive the change to which we allude.

It has already been intimated, that simultaneously with the operations of König, and Cowper, and Applegath, Messrs. Donkin and Bacon were employed in the invention of a machine for type printing by means of rotary motion. These gentlemen so far carried out their most ingenious but complex design, that in 1818 they obtained a patent, and afterwards had the satisfaction of witnessing the successful operation of one of their beautiful machines, which was erected for the university of Cambridge, where, for some time, it was used in the printing of their stereotype Bibles and Prayer-books. According to Mr. Cowper, however, it was found to be too complicated; the inking was defective, which prevented its success; and there are now none of these machines in use. Nevertheless, a great point was attained; for in this machine were first introduced inking rollers covered with a composition of treacle and glue, whereas in König's machine the rollers were covered with leather, which never answered the purpose well.

In this machine, the patent specified the fastening of the pages of type to the surface of a prismatic cylinder having any number of planes from four to eight: to these types the ink was immediately supplied by a large elastic roller placed over the type cylinder, and made to rise and fall in accordance with the irregular motion of the surfaces of the latter; two other and smaller rollers conveyed the ink from a receptacle to the large roller. The sheet of paper to be printed was applied to another revolving prism, composed of segments of cylinders exactly adapted to meet the irregularities of the type roller. To ensure those niceties and irregularities of motion and of contact required in printing, toothed wheels, corresponding in shape to the prisms, were placed upon the axis; and however strange, at first may appear to non-mechanical persons the working together of metal wheels of such angular shapes, by providing for a free vertical motion of the gudgeons of each roller the operation of the whole machine was steady and uniform. The diagram in the margin, representing a section of the principal parts, will enable the reader to form a more correct idea of this curious machine.

Fig. 18.



A, the quadrangular prismatic roller, with its surfaces of stereotype plates, as in the Cambridge apparatus.

B, the roller for distributing the ink, which it receives from the two smaller rollers *a e*, in contact with the box *i*.

C, the pressing cylinder, covered with cloth or felt.

D E, the track of the paper in the direction of the arrows. This figure is taken from a cut in the lecture already mentioned, in which it occurs with eight or nine similar diagrams, illustrative of the progressive improvement in printing machines, from Nicholson's original method with arched type, to the perfect apparatus of Applegath and Cowper.

CHAP. IX.

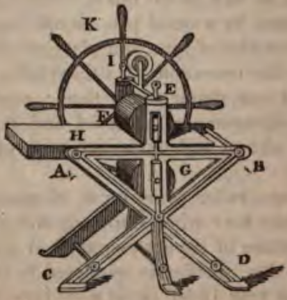
COPPER-PLATE AND OTHER PRESSES.

WOODEN ROLLER PRESS FOR PLATE PRINTING. — HOW USED. — CAST IRON ROLLER PRESS. — DYER'S PATENT PRESS FOR PRINTING WITH PERKINS'S PLATES. — LITHOGRAPHIC PRESS. — STANDING PRESS. — ATHOL AND HYDRAULIC PRESSES. — COPYING MACHINES. — HAWKINS'S POLYGRAPH. — OTHER CONTRIVANCES FOR COPYING LETTERS.

THE present chapter, although introduced under a new head, must, in fact, be considered as a continuation of the preceding one on iron printing machinery in general. A few years ago, the terms "screw press," and "rolling press," or "type press," and "plate press," would have indicated with sufficient distinctness the methods of printing, and the kinds of presses then in use. Such, however, have been the alterations and inventions of late years introduced into the manufacture of machines for multiplying impressions on the principle of printing, that the roller is applied to the type form; the screw to the process of copying autograph letters; plates are cast in stereotype, as well as cut out of rolled copper or steel: and even stones, by a novel process uniting in some degree the two modes of type and plate printing, are made to yield, by the operation of lithography, a variety of exquisite and surprising productions; combining, with the utmost cheapness of material and facility of execution, the almost unbounded exercise of the arts of design.

The common roller press must, of course, have had its origin at the time when impressions first began to be taken from plates of copper engraved or etched on the surface, and this practice is supposed to be at least as ancient as the year 1540, about a century later than the date usually assigned to the invention of printing from movable types; though it has been said, that the art was not employed in England before the reign of James I., having been brought over from Antwerp by Speed, the antiquary. The old wooden rolling press, and which appears to have undergone little alteration in general, is an exceedingly simple contrivance, consisting of two rollers, six inches or more in diameter, having trunnions or axles passing through the upright supports, and made to revolve by means of a cross, consisting of two levers, attached to the axle of the upper cylinder. Between these cylinders passes a board, called "the plank," upon which the plate, charged with ink, is laid to be printed from: the impression is produced by placing the paper, properly damped, over the plate, and then, by means of the cross levers, drawing the plank, with the plate and paper lying upon it, between the rollers; the uppermost of which, being covered with blanketing, forces the paper, as it were, into the interstices, and the ink adhering, an exact impression of the design on the metal is the result. Of these machines, constructed mostly of wood, many have been made with improvements, and at a very great expense, in modern times. They are now, however, manufactured of cast iron, by most of the iron press makers, and are made to

Fig. 74.

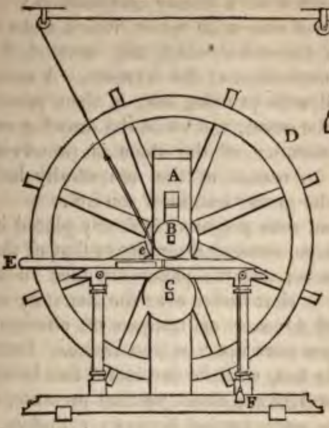


combine simplicity, cheapness, and efficiency, to a degree that has rendered them very common among engravers, whose means might have rendered difficult of attainment machines equally convenient and durable of any other material.

Fig. 74. is a representation of a cast-iron press adapted for printing from copper plates: although not so massy as to require the sinking of a considerable sum in mere weight of metal, it is nevertheless so stout as to answer efficiently the purpose for which it is designed. The whole fabric weighs about eight cwt. A B C D E indicate one side of a strong cast-iron frame, the width from A to B being, in the machine from which the description is made, three feet, and the height from the floor to the top of the pillar E four feet three inches. The two sides of this frame, which exactly resemble each other, are bound together by cross bars of wrought iron, fastened with nuts and screws at their extreme ends. F G are two cast-iron cylinders or rollers, two feet in length, accurately turned on their surfaces at a slide lathe, and working on iron axles passing through each side of the frame. The upper roller is nine inches and the lower one twelve inches in diameter. H is a stout plank of mahogany, or other hard wood, two inches thick, faced with plate iron, and about the width of the rollers; upon this the engraved plate is laid, when an impression is to be taken. The axles of both rollers rest upon brass bearings, which rise or fall in grooves, as seen in that side of the frame next the eye. At E, and in the corresponding upright on the other side, are screws to regulate the pressure of the rollers upon the plank; and, consequently, upon the plate laid thereupon. I is a pulley in a frame, upon a cross piece over the upper roller: its use is to carry a weighted string, for the purpose of detaining upon the cylinder the blanket, which, on being pressed upon the plate by the action of the rollers, effects the impression. K is a metal wheel, or cross lever, fixed on the axle of the upper roller: the handles or grips form levers, each of two feet six inches in length from the centre of the roller

In Dyer's patent for Perkins's plates and presses, obtained in 1810, we find some striking improvements. I the following section of the machine, as constructed b Mr. Dyer, we find substantially the parts of that abov described,—as the upright support A, the rollers B C and the lever wheel D. Instead, however, of the soli plank marked H in the former article, there is Mr. Dyer's press a sliding table E, to the farther end which, and passing over a pulley, is a string with weight F attached, sufficient, when the table has bee advanced, to bring it back to its present position whe not acted upon by the roller. In this table at *e* the is a cell, containing a cast-iron box, for the purpose containing a heater. A perforated plate rests in th rim of this box, above the heater; and upon it the engraved plate is placed, and may be kept at a proper temperature for a considerable time, without changing the heater or removing the plate, which obviates the inconveniency that would otherwise attach to the printing of thick and heavy steel plates. A still further improvement has been, the placing of a little stove with charcoal immediately under that part of the table upon which the plate is fastened, by which means an equal temperature is maintained in the plate, by its resting over this stove during every repetition of the inking process. Steam has still more recently been applied with success for heating copper plates when used for printing. The operation of the sliding table is as follows:—The upper roller, instead of being a perfect cylinder, has, in one part of its periphery, a flat space, or, in other words, a portion of the material is cut away through the whole length of the surface. This being the case, it will easily be perceived, that, by turning the wheel, the table E is drawn between the cylinders, the counterpoise F rising accordingly; but that, on the upper cylinder having passed over the plate, and then presenting that part of its surface where it is cut away, it ceases to bear upon the table, upon which the weight immediately acting draws it back to its former position, when the impression is removed, fresh ink and paper applied, and the operation renewed as before.

Fig. 75.

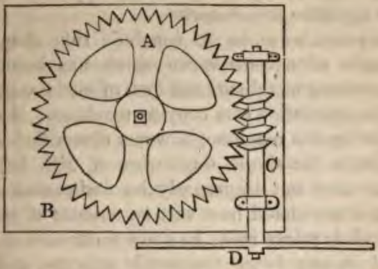


It might be deemed an omission in this notice of iron printing machines, were we to make no mention at all of the lithographic press; since its use in this country has not only become common of late years, but some of its productions are highly deserving of the admiration that has been bestowed upon them. The instrument, however, by the means of which impressions are taken from stone, as the name given to this art implies, although differing widely from those used in both letterpress and copper-plate printing, is only in a slight degree indebted to the smith for its materials or construction. We owe the discovery of this mode of printing to Alois Senefelder, a student of jurisprudence in the university of Ingoldstadt, in Bavaria, who, at the close of the last century, obtained impressions of music, drawings, and writing by this method. The principles on which it is founded are, first, the quality which a compact granular limestone has of imbibing grease or moisture; and, secondly, the decided antipathy of grease and water for each other. A drawing or writing is traced on the smoothed surface of the stone, either with proper ink, or with a crayon of a greasy composition: the surface is then washed over with water, which sinks into those portions of the stone which are untouched with the unctuous composition of the drawing. A roller, or dabber, charged with printing ink, is then passed all over the face of the stone; and while the drawing receives the ink, the remainder of the stone is preserved from it altogether, by reason of the non-affinity between the water and the greasy nature of the ink.

The stone, thus prepared, is firmly placed in a sliding bed or carriage, somewhat similar to that of the common printing press; and the paper designed to receive the impression is shut down over the stone, by means of a frisket, and a cover or tympan of strong calf skin, stretched by screws upon an iron frame. Instead, however, of this bed, with its furniture, &c. being brought under a powerful and direct vertical pressure, as in type printing, or even carried between cylinders, as at the copper-plate press, it is made to pass under what is called a scraper,—an edged piece of hard beech wood, borne down, by a contrivance of levers, upon the calf-skin cover, with so much force that the paper underneath receives an impression as the whole passes under the operation of this scraper. The bed or carriage is drawn along by means of straps attached to it, and winding upon a roller, turned by what is called a star-wheel, or a six-armed lever, similar to those already described as usually to be seen at a copper-plate printing press.

Every letter-press, copper-plate, or lithographic printer, besides the machine for multiplying impressions, has what is called a standing press, formerly made of wood, but now more generally of iron. It usually consists of strong uprights or cheeks, with bed and top pieces: through the latter, which is furnished with a brass box or worm, passes a strong screw, to the lower end of which is suspended a plate, or platten, and the use of which is to smooth the printed sheets, by placing them separately between polished pasteboards, and then squeezing them down very closely; this being the operation to which the pages of a printed book are indebted for that peculiar smoothness which fine works present. To bring the screw down with the requisite force, a long iron lever is used; or, as in the Athol press, a more ingenious contrivance is resorted to for that purpose. To the bottom of the main screw, where it connects with the iron plate or platten, instead of the knob with holes for the insertion of the lever, there is affixed a large toothed wheel A, which lies horizontally upon the platten B (see *fig.* 76.), and in the teeth of which works a screw C, having on the near end of its axle a three-armed or rather a three-legged lever, D; for it is ornamentally cast in one piece, after the fashion of the well-known arms of the Isle of Man, of which the dukes of Athol were formerly sovereigns, and from whom the press is named.

Fig. 76.



Another, and by far the most powerful machine for pressure that is known, owes its peculiarity to the application of Bramah's celebrated hydraulic engine. In this press, as the piston is forced upwards, the things to be pressed are placed upon an iron table, and forced against a head-piece, strong enough to resist the immense power which the press on this construction is calculated to exert. The Athol standing press is an exceedingly handsome, useful, and powerful contrivance, especially for the bookbinder; but those who compare it with the hydraulic, on the score of power alone, can only do injustice to its merits.

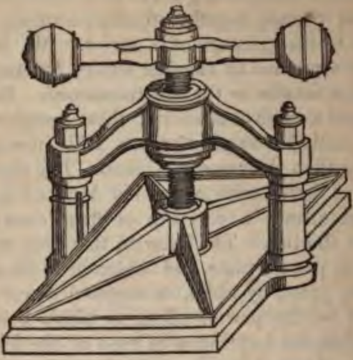
It may not be amiss to conclude this chapter with some notice of a contrivance which has become very common among merchants and men of business generally, under the appellation of a copying machine. As the object in using this machine, however diversified its form, is to obtain fac-simile duplicates of MS. letters, the operation may not improperly be designated printing. When it is considered how vast an amount of writing in letters and invoices must be daily accumulated and despatched in any large mercantile concern, and at the same time how desirable it is that most, and absolutely necessary that much, of this writing should be copied, the importance of any invention to save the time of clerks with reference to this tiresome and often unprofitable labour must immediately become apparent. Accordingly, the schemes that have been published, within the period of a century, having for their object the multiplication of written letters without the trouble of transcription, may be said almost to have equalled, in number at least, the machinery for letter-press printing.

One of the most early and obvious applications of a contrivance for the purpose alluded to, would of course be that of impressing, by means of a rolling press, one letter, before the ink with which it was written became quite dry, upon the surface of a blank sheet of writing paper; the latter receiving the impression of the original with a sufficient degree of distinctness to admit of the matter being read, either backward, from the right hand to the left, or, if the paper were very thin, in the usual manner, by holding the copy up to the light, and reading through the paper. In 1780, Mr. Watt obtained a patent for an improvement on this process. His method was to place a thin unsized sheet of paper, wetted, between two woollen cloths, which absorbed the unnecessary moisture. This paper was then laid upon the surface of the letter to be copied, whilst the writing was recent; the sheets were then either pressed together through a rolling press, or subjected to the pressure of a screw. Mr. Bell had a patent for a method of copying letters, &c. into a book, by a process similar to the last mentioned. Dr. Franklin proposed a method of making these transfers, which, although ineligible in practice, was still more analogous to printing than the preceding plans. The doctor wrote the original letter with a gummy kind of ink, upon which was strewn a covering of flour emery, which adhered to the ink. The letter in this state was placed on a smooth pewter plate, and subjected to the operation of a rolling press, by which an impression was made by the emery on the pewter plate, to which printing ink being applied, an impression or copy of the letter could be taken on damped paper.

The method most commonly practised in mercantile houses is to take the impressions in a book of unsized paper, through each leaf of which the prepared ink of the autograph letter so completely strikes, as to render the fac-simile perfectly readable on either side. The press used in this operation is entirely of iron, often got up with great neatness, and of the form represented by the subjoined figure (*fig.* 77.): the platten and bed are, of course, adapted to the size of the paper to be copied. In using the machine, a leaf of damp copying paper is laid upon every page to be copied, with a sheet of dry oiled paper: these are then placed within the press book, and the whole submitted to such a pressure as a man of moderate strength can give without difficulty.

The press has been in some cases dispensed with altogether, either by the use of tracing paper, or a metallic foil placed under the sheet during the writing, or by means of Hawkins's polygraph. The latter is a somewhat complex machine, consisting of a peculiar frame-work carrying two pens, and so connected by joints, that whatever motion is given by the hand to one pen the other pen describes a similar figure; by which contrivance, whilst a person is employed in writing a letter with one of these pens, the other makes a copy on a separate sheet of paper. In 1806, an individual of the name of Wedgwood obtained a patent for a plan of producing duplicates as follows:—A sheet of paper is blacked over on both sides with printers' ink, and afterwards placed for five or six weeks between leaves of blotting-paper to dry. A sheet of letter-paper being laid on a smooth pewter or copper plate, the blackened paper is laid upon this, and above, a leaf of thin paper oiled to make it more transparent. On the paper thus arranged the person writes with an agate style, ground and polished to a smooth neat point. The letter-paper receives an impression from the blackened sheet, which, as the writing is in the right direction, is used as the original, while the upper or oiled paper presents the impression reversed, and must of course be read through the paper.

Fig. 77.



CHAP. X.

HAND MILLS AND MANGLES.

ANTIQUITY OF MILLS. — FRENCH MILITARY MILL. — CYLINDER, OR BRUISING MILLS. — CUTTING MILLS. — COMMON COFFEE MILLS. — TERRY'S MILL. — POLLARD'S EPICYCLOIDAL MILL. — COMMON MANGLE. — IRONS, AND CRIMPING MACHINES. — BAKER'S PATENT MANGLE. — PECHY'S AND CHRISTIE'S MANGLES.

Hand Mills.

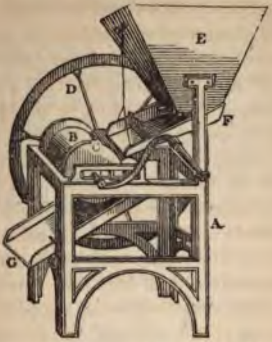
THE machines named at the head of this chapter are mentioned together, not on account of any direct resemblance — for, with the exception of the crank handle and fly wheel, they have few parts in common with each other — but because they may be regarded as coming generally under one class of manufactures. Of these useful contrivances, mills are undoubtedly the most ancient, the most indispensable, and consequently the most largely in demand. The theory and construction of mill-works, in the large and usual acceptation of the term, belongs to engineering; and a volume, rather than a chapter, would be required for their most compendious elucidation. In the present article, therefore, it is intended merely to mention some of those machines for the comminution of various substances, which are put in operation by the hand, having generally a rotary motion and a fly wheel; and which, as they are in universal requisition, constitute a considerable item of our local manufactures in iron and steel, as connected with the useful arts.

The word *mill* is often used in a very loose acceptation, even by professional writers; hence we have rolling mills for the flatting of metal, flour mills for the grinding of corn, sawing mills for the cutting up of timber, and oil mills for the pressing of oleaginous seeds—all differing widely in their principles. The most ancient mills were undoubtedly those in which the method of levigation was rudely employed: of these, the muller, somewhat resembling the common stone mortar and pestle, is the simplest form, and our best flour mills the most perfect exhibition. As almost all the mills for grinding corn, colours, &c. depend upon the principle of attrition between two stones, the description of them does not belong to this place. There is, however, one machine, which, no less on account of the ingenuity displayed in its construction, and the circumstances which brought it into notice, than with respect to its materials, merits a passing notice. We refer to the French military mill—so called from having "formed part of the camp and field equipage of the immense army with which Napoleon invaded the Russian empire in the year 1812; an expedition which, for the vast ambition which dictated it, the gigantic efforts by which it was organised, the military skill and experience of its conductors, and, finally, for the combination of disastrous events which characterised its progress, and terminated in its failure, is perhaps unparalleled in the annals of history." In this machine, cut plates of steel are used instead of stones; and in 1824, Messrs. Taylor and Jones, of Cheapside, obtained a patent for a "circular steel corn-mill," on the principle of the foregoing, and including some improvements. This machine, they state, is calculated to grind barley, beans, and other descriptions of grain, as well as wheat—though undoubtedly it may be considered in the most useful and interesting point of view, as a portable mill for the production of bread-flour.

The mill adapted for the crushing of malt, sugar, &c. consists of two cast-iron cylinders, having their surfaces turned exactly true with the slide lathe, and placed parallel to each other in an horizontal position; their axles being at the same time so arranged in sliding beds, as to admit of the surfaces of the cylinders being brought nearer to one another or removed farther apart, as required, by means of a regulating screw.

The following cut (*fig.* 78.) represents a stout and

Fig. 78.

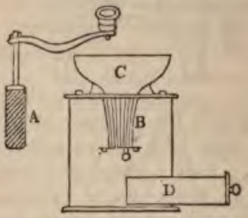


useful crushing mill for ordinary purposes; the whole machine is of iron, with the exception of the hopper and the spouts. A is a cast-iron frame, put together by screws; B C, the crushing cylinders; to the axle of the former is attached the handle for giving motion to the mill. At each end of this cylinder there is a deep flange or margin, which, by embracing a portion of the other cylinder, prevents the matter about to be crushed from flying off. Upon the axle of the second cylinder is fixed the fly wheel D; the two axles on that side are connected by cog wheels, in order to equalise the revolution of the crushing rollers. A hopper of wood, E, receives the malt, or whatever substance is ground; and F, a spout, is so disposed, that, by the shaking of the mill, the contents of the hopper are scattered between the cylinders. Another spout, G, receives and conveys away the bruised charge.

Mills for splitting or cutting beans for horses are constructed on a principle similar to the foregoing, with the difference, that instead of large cylinders having smooth surfaces, there are solid rollers of less diameter, and cut with longitudinal and somewhat oblique grooves, so as to present a series of acutely angular edges, between which whatever substance passes is more or less masticated, as the cutting of the rollers happens to be fine or otherwise.

The mill used in grinding coffee, whether its appearance be that of an ornamental box, as seen in many private families, or of black iron, as fixed in the grocers' shops, is formed on a principle denominated the *quern*. A solid piece of hard metal, of a conical figure, and grooved on the surface, as represented below (*fig*. 79.), A, having an axis passing through it for the purpose of fixing and giving motion to the quern, is a principal part. This cone is either made of steel, cut with a chisel, and then hardened, or cast of chilled pig iron, and then sharpened a little by dressing. This quern is fixed so as to revolve within a box of steel or cast iron, B, having on its inside sharp grooves, similar to those on the piece last described, but smaller. In using these mills, whether held horizontally, as is the case with most of the portable ones, or placed vertically, as those fixed in shops and kitchens commonly are, the substance to be ground, on being put into the cup or hopper, is gradually caught and crushed to powder by the revolution of the inner cone, the grooves upon which, running obliquely, act as a screw during the turning; the coffee when ground falling into the little drawer D. The outer cases of some of these mills for grinding

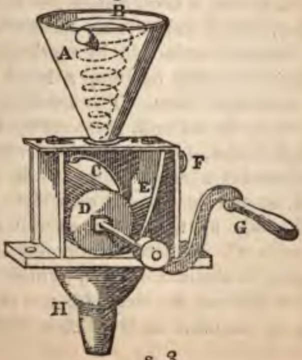
Fig. 79.



coffee are, as already stated, made of mahogany or japanned metal; and of one of these the sketch in the margin is a section: they are not less ornamental than useful accessories of the breakfast room in many houses, the flavour of the coffee being supposed to depend in no small degree upon its being ground immediately before its infusion. In general, however, coffee is ground by what is called a flanch mill, having the body composed of rolled iron, and being screwed against a post in the kitchen, in the same manner as we often see it in the retail shops. In consequence of the general use of coffee as a breakfast luxury, a prodigious quantity of mills of this description are manufactured in this country, more particularly in the town and neighbourhood of Birmingham; nor is the consumption of them at all inferior in the United States, if we may believe an American author, who says that upwards of 200,000 coffee-mills are annually made at Middletown, in Connecticut.

Several years since, the Society for the Encouragement of Arts, Manufactures, &c. rewarded an individual of the name of Terry for an improved iron mill for grinding hard substances. The following is a description of Mr. Terry's mill:—(*Fig.*80.) A is the hopper; B a spiral wire

Fig. 80.

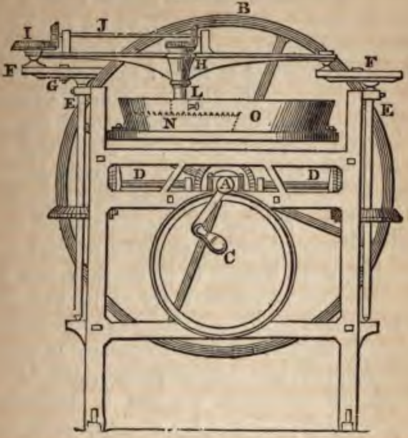


in the form of a reverse cone, to regulate the delivery of the articles to be ground; C an inclined iron plate, hung upon a pin on its higher end; the lower end rests on the grooved axis D, and agitates the wire B; D is the grinding cylinder, which acts against the channelled iron plate E; F a screw on one side of the mill, by means of which the iron plate E is brought nearer to or removed farther from the axis D, according as the article is wanted finer or coarser; G the handle by which motion is given to the axis; H the tube whence the articles, when ground, are received. The plate on the side next the spectator is removed in order to admit of a view of the works inside. Mills for the rasping of logwood and other similar substances for dyeing usually consist of a toothed cylinder, either cut like a file, or composed of a series of circular saws, screwed together upon an axis, so as to form an exceedingly keen and durable cutter, against which the wood is made to bear, and, at the same time, is constantly driven up as the rasping goes on, by means of weights.

Paint is commonly ground by means of a stone muller; of the adaptation of which, the hand indigo mill, and Mr. Rawlinson's and other colour mills, furnish ingenious examples, though their particular description does not come within the design of this work.

There is, however, a contrivance for the purpose of grinding paint, which exhibits so successful an application of a beautiful principle in mechanics, that, as its construction is chiefly of iron, a brief notice of it may not be misplaced here. The machine alluded to is the patent epicycloidal mill, invented by Mr. Pollard, of Thornhaugh Street, London, and of which the annexed cut represents a front view. A is a horizontal shaft or axle, at the farther end of which is a regular fly wheel B, and, at the end next the spectator, a common handle C, by which the mill is actuated; D D are two horizontal shafts, which are turned by the bevel wheel on the shaft A; and, by means of bevel wheels on the other ends of these shafts, the two vertical crank shafts E E are turned: on the top of these crank shafts are moving crank heads F F, with a chase mortice in each; and, by unscrewing the nuts

Fig. 81.



G G, both of these crank heads can be slid with the sliding index H either backwards or forwards; by which means the scope of the two cranks can be either lengthened or shortened, which will cause the circular runner to traverse over, in its epicycloidal course, a greater or less course in the iron or marble pan, or flat bedstone O, as may be required when grinding any quantity of colours or other material. This pan, or bedstone, measures two feet six inches by two feet two inches wide; the two ends of the sliding index H are fixed on the two crank heads F F; and on that part of the crank head which passes through the end of the sliding index is fixed the bevel wheel I, by which is put in motion the horizontal shaft J, that is attached with bevel gear to the top of the sliding index H. K is the central perpendicular shaft, moving in the box of the sliding index; this central shaft has a bevel wheel on the top, which is put in motion by the gear of the small horizontal shaft J, which receives its motion from the bevel wheel I on the crank head, by which means a rotary motion is given to the central perpendicular shaft K. The lower part of the central shaft is square, on which the iron box M is fitted, which can be moved up and down the square part of the central shaft, when the box is not fastened to it by a nut screw, L. N is the circular runner; its diameter must necessarily be one inch larger than half the diameter of the iron or marble pan, O, or flat bedstone, in order that in traversing the epicycloidal course its extremity may always pass over the centre of the pan or flat bedstone. In the centre of the circular runner N is fixed a square iron pin, terminating rather conically towards the top, in order that, when the pin is in the iron box M, the circular runner N may always act on its own level on the materials then grinding in the pan or bedstone; the mill, when in motion, causing the runner to produce a combined elliptical and circular motion, and to traverse an epicycloidal course in the pan or bedstone. By these motions, the colours, &c. are constantly removed from the crown into the centre and about the surface of the pan, thus rendering their quality the finest possible with the greatest ease and despatch.

Mangles.

Analogous to the practice of giving a smooth shining appearance to a variety of woollen, linen, cotton, and other fabrics, by the process called calendering, which consists in passing a piece between polished rollers, is the well-known operation of the laundress called mangling. As, however, a mangle is not only an expensive machine, but one which can only be used with success upon things having some tolerable degree of strength, and such as admit of being wound on a roller, every housewife resorts more or less to what is called ironing, for the purpose of giving smoothness to various articles, more especially of wearing apparel, after they have been washed. The method of using the smoothing iron belongs, of course, to the economy of the laundry; and yet, as the irons themselves are now found in every house in the kingdom, and, therefore, constitute a considerable item in the furnishing ironmongery business; and as their use is, in fact, identical with that of the mangle; it can hardly be deemed irrelevant in this place briefly to allude to an article, the casting of which in a northern county is said to have been the nucleus of what ultimately became one of the most important foundery establishments in the kingdom. Dealers commonly distinguish these useful implements by the terms "sad iron," "box iron," and "Italian iron." The former is, as the epithet signifies in the north, solid, and therefore generally made hot for the purpose of being used by placing in a bracket against the bars of the grate. The second, which is calculated for more delicate uses, is made hollow, for the reception of a heater; and, with reference to the contrivance by which the heater is shut in, has been called the "floodgate iron." The reader of Boswell's "Life of Johnson" will recollect an amusing story which the doctor told, about the important airs which a man, calling himself the inventor of the floodgate iron, once indulged at an inn where he called. The box has been, of late years, almost superseded by the more convenient Italian iron, which is a tubular metal box, with a round end, neatly mounted on a stand, and its temperature kept up by the insertion of a heater. In using the two former irons, the laundress rubs them upon the linen, &c.: the application of the latter contrivance, however, is by drawing over it the piece intended to be smoothed or set. Even this latter article has been somewhat superseded by the introduction of what are called "crimping machines," and the manufacture of which at this moment is far from inconsiderable. These machines consist of two brass barrels, about eight inches in length and an inch and a half in diameter, each being cut or fluted longitudinally with triangular ridges or gutters, exactly working into each other in the manner of cog wheels. These cylinders, made hollow for the reception of heaters, are neatly mounted in a frame of iron, and made to revolve by means of a handle. Between the portion of the rollers, which project for that purpose beyond the side of the frame, is passed whatever is intended to be crimped, as strips of lawn, &c. For much of the neatness and variety which so many of our fair countrywomen display in their muslin frills and flounces, they are indebted to the ingenious contrivance of the Italian iron and the crimping machine.

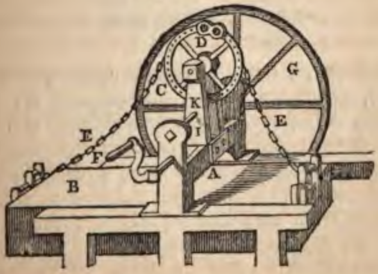
There is reason to believe that heated irons to plait the drapery are of very great antiquity among the Greeks and Romans. With reference to our own country, Stowe says,—"About the sixteenth yeere of the Queene [Elizabeth] began the making of steel poking sticks, and until that time all the laundresses used setting sticks of wood or bone." This was the period when large stiff ruffs were in vogue; and almost contemporaneous with the improvement in "poking sticks" mentioned by the antiquary, as we are told by another authority, namely, in 1564, one Mistress Dingham van den Plasse, a native of Flanders, came to London with her husband, and followed the occupation of a starcher with no less profit than celebrity.

The mangle, as above intimated, has long been used either with or substituted for the sad iron, in the smoothing of heavy articles, especially such as may without injury be folded up and submitted to pressure, as sheets and table linen. These, being wrapped upon wooden rollers, are submitted to the operation of an oblong shallow box, which is weighted with several cwt. of stones or other ponderous materials; this box being moved backwards and forwards upon a level, by means of a handle attached to an upper roller or windlass, to which straps from each end of the moving box are attached. By this machine the operation of mangling was well enough done; but the labour of keeping the box in motion was excessive, not only on account of the power required, in the first place, to overcome the *vis inertiæ* of the weighted box, but alternately to arrest and reverse the motion, when considerable velocity has been communicated by its passage over the rollers; and added to this, the short distance in which all this had to take place; the velocity of the box no sooner yielding a momentary relief to the turner, than it became necessary to reverse the motion: on these accounts, mangling, which was not only performed by servants in private laundries, but by which great numbers of widows and other poor women earn their livelihood, was a most laborious occupation.

To Mr. Baker, of Fore Street, Cripplegate, the public is indebted for a most ingenious and important improvement in the construction of mangles; an improvement which, by rendering it only necessary to keep turning the handle *one way*, and by adding a fly wheel to equalise the motion, a vast amount of muscular exertion has in consequence been saved to the person working the machine. This estimable invention, which has in so large a degree superseded the old wooden windlass and girths, consists in an application of iron machinery, the nature of which is sufficiently curious and useful to merit a practical explanation.

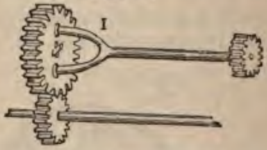
In the annexed representation (*fig.* 82.), A is a bridge

Fig. 82.



of cast iron, passing over the top of the weighted box B, and resting on the frame on each side. In the centre of this bridge stand two upright pieces, seven inches apart, and supporting the wheel C. This wheel, which is twenty inches in diameter, has a series of sixty wrought-iron pegs, projecting about an inch, and the like distance apart, inserted in its front surface. These pins do not run quite round, but an interval of about three inches and a half is formed at D, through which a pinion works, when traversing from the inside to the outside of the pins, and *vice versâ*, during the reversing of the motion, instead of confining the pinion to one course, as when working on an ordinary cog wheel. Over the periphery of this wheel passes a flat chain E E, crossing underneath, and attached to the ends of the mangle box: F is the winch handle, by means of which the motion is communicated; and G a stout fly wheel, of about four feet in diameter, which assists and regulates the operation. The axle, upon the extremities of which the handle and wheel are fixed, lies along a gutter in the bridge above mentioned. Near the end of the axle, next the handle, is a pinion which works in a cog wheel of six inches diameter, lying within a recess in the circular head of the near support H; the last-mentioned wheel turns on a short pivot, and has two holes in its face, into which is loosely inserted the forked end of an axle I, having at its further termination a pinion, which acts upon the pegs of the large wheel. This end of the axis passes through a slit, K, in the near centre upright; by which contrivance it has a ver-

Fig. 83.



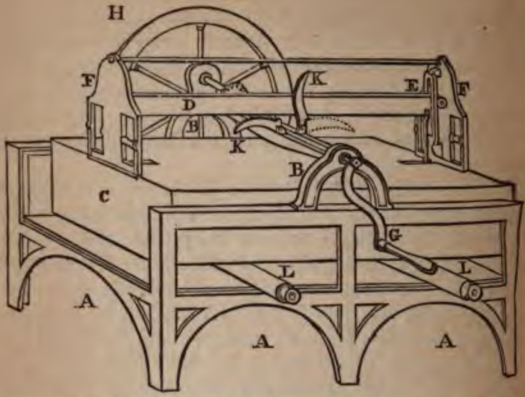
tical motion, sufficient to allow the pinion to pass up and down from one side of the circle of pins to the other.

If the foregoing description be understood, it will be seen that, on the machinery being put in motion by turning the handle, the pinion of the axle I traverses the circle of pins on the wheel, until, coming to the gap at D, it turns round the last pin, sinks or rises in the slit, and thus reverses the motion of the wheel, and, by means of the chain, that of the box likewise; the handle and fly wheel still turning in the same direction as before.

Subsequently to Mr. Baker's invention, a variety of contrivances for the attainment of a similar result have been introduced to the notice of the public; two or three at least of them through the "Transactions of the Society of Arts." The most interesting and useful of these deviations from Mr. Baker's plan have been a substitution of an endless rack for the peg wheel, and the abandonment altogether of the flat chain above described. In 1823, Mr. Pechey received a silver medal from the aforenamed Society for a mangle on the last-mentioned principle. This mangle, of which the model may be seen in the Society's repository in the Adelphi, had what might be called a hollow or inside rack, resembling, in fact, two racks with their teeth placed opposite, so as to form parallel lines; the pinion working between them, and of course catching only on one side, and being fixed so as to play up and down, as in the case of Baker's machine, for the purpose of taking each side of the rack in rotation.

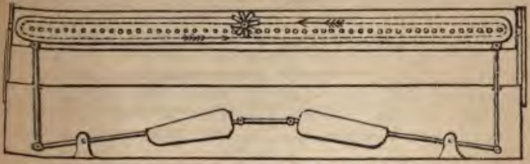
One of the most perfect mangles of this description which has been presented to the public, is manufactured by Christie and Co. of Sheffield, and of which the annexed cut is an accurate delineation. This mangle, which, with the exception of the bed, the under boards of the box, and the rollers, is made entirely of cast and wrought iron, is said to be cheaper; and it is certainly much more than it would be if, with the exception of the machinery, it were constructed of wood so stout as to afford a similar degree of substantiality. A A A, the frame of cast iron, with cross piece and bridges, B B, to

Fig. 84



support the handle; C, the cast-iron box, filled with large stones or gravel to give it weight; D, the rack, which is made to move up and down at each end in projecting grooved or slit pieces, as represented at E, and attached to vertical plates, FF, rising from the box. This rack is a stout metal bar, with a row of pegs along the middle of one side; and parallel with the line of these pegs projects a deep flanch or margin, intended to confine a pinion to its hold upon the pins while traversing the rack, or rather while moving the rack backwards and forwards by acting successively on each side of the series of pins. As the front of the rack is not shown in the foregoing engraving, and as the manner in which it is balanced so as to produce a vertical and reciprocating motion through its entire length, when the pinion passes from side to side, is curious, the following figure will be useful to explain this contrivance. It will be seen at once, on an inspection of the cut, how, in consequence of the rack being attached by each end to the connected levers, and counterpoised by the weights inside the mangle box, the pinion can traverse, in the

Fig. 85.



direction of the dots and the arrows, the row of pegs along the middle. It will be obvious, that when, by the progression of the rack from the right hand to the left in the figure, the pinion passes round the endmost peg, the rack will be lifted up, the weights in the box will sink, and the course of the pinion will be along the under side of the rack, until, on arriving at the last pin at the opposite end, the rack will again sink, the counterpoise rise to its present position, and the motion of the box be thus reversed, with every alternation of the rack. To return to the former cut:—

G is the handle, and H the fly wheel fixed on the opposite end of the axle, adjoining the centre of the fly wheel, which, acting upon a circle of cogs in the head I, gives revolution to the pinion which carries the rack, and the upper part of which is seen in the figure; K K are two iron prongs, either of which, on being turned down, as that to the left is represented, lift up and sustain the end of the mangle box when the rollers are to be taken out; L L the rollers, upon which the articles to be mangled are wrapped.

CHAP. XI.

AGRICULTURAL AND WEAVING MACHINES.

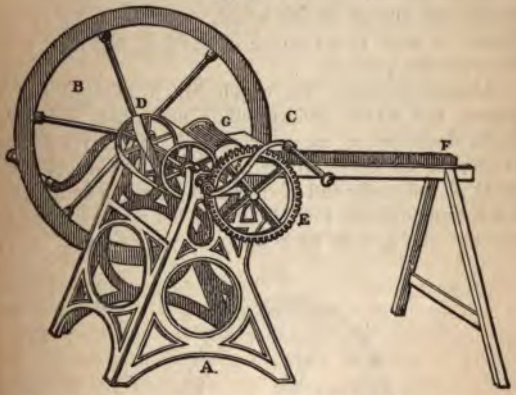
CHAFF CUTTERS. — CORN AND GRASS CUTTING MACHINES. — CRUSHING MACHINES. — COTTON MACHINERY. — FLAX MACHINERY. — SILK WINDING MACHINERY. — WOOLLEN MACHINERY. — THE WARPING MILE ROPE MACHINERY.

So much advantage has been found to accrue from cutting the hay, straw, &c., given with bran and other lick to cattle, that what are called chaff boxes, having a cutting knife somewhat similar in size and shape to the blade of a scythe, having long been common in almost every part of England. These chaff knives are generally manufactured by the scythe makers throughout the country: they are fixed for working at the end of a long box or trough mounted on legs, and containing the straw or other material to be cut. The lower end of the knife being attached to a sort of treadle, the workman, in making each cut upon the straw, assists the descent of the blade by bearing upon the treadle with his foot. The straw, which is kept compact in the box by means of a weighted board lying upon it, is advanced so as to fall under the action of the knife by means of a fork attached with strings to the fore end of the box, and managed with the left hand. Mr. Braby, of Lambeth, manufactured these machines on an improved principle, by placing across the trough, over the pressing board, a roller, upon which the strings from the fork were made to wind; and, by means of ratchet wheel and a click connected with the treadle, the straw was made to advance after every stroke without other assistance, thus leaving the labourer the additional power of using the knife with both hands.

Although this old-fashioned "straw chopper," as it is called, is still every where in use among cattle-keepers of the poorer sort, it has long been superseded, with the more competent class, by machines in which knives ar made to act in connection with rotatory motion. Of these machines there is now considerable variety as to their several parts, though in general they agree in the main principle with one or other of the following contrivances: —

Fig. 86. represents a chaff cutter in common use, the entire of which, with the exception of the box and two legs, is of iron, and therefore very substantial and durable; A is the frame or support, and B the fly wheel, both of massy cast iron; C C are handles by which motion is communicated to the machine; upon the axle carrying the fly wheel, and to which these handles are attached, and between the upper ends of the support, are fixed two stout iron wheels, D, to the inside rims of which are fastened, at equal distances, four knives; these knives are placed obliquely to the axle above mentioned, so as to operate with a sort of draw cut upon the matter presented at the end of the box, and at the same time to follow each other in such quick succession that their effect is almost uninterrupted, one knife beginning to cut at its advanced part nearly at the mo-

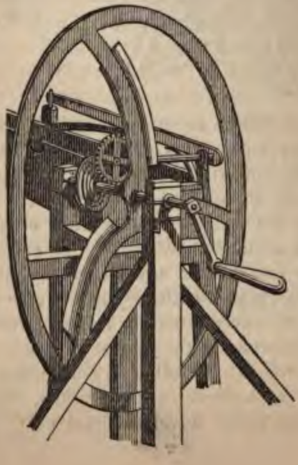
Fig. 86.



ment the preceding one has completed its operation. Connected with the main axle by means of a pinion, is the cog wheel E, to which is attached a grooved roller working underneath the feeding box F, and answerable to this, on the upper part, another roller represented by G; between these rollers the straw, or whatever substance it is intended to mince, is slowly drawn, and its extremity just protruded beyond the end of the box, so as to come under the operation of the knives. This machine has very great power, in consequence of the weight and size of the fly wheel, and the placing of the knives so near to its centre of motion, together with their oblique position.

Another machine, for which Mr. M'Dougall had a patent, and which divides public patronage with that above described, is constructed by fixing knives to two or more of the spokes of the fly-wheel; the wheel itself being placed at the end of the feeding box, so as to form a right angle therewith. The annexed representation of the fly wheel, with its accompanying knives — which

Fig. 87.



in M'Dougall's machine are three, and bent so as to give obliquity to the cut — will enable the reader to form a pretty correct idea of the contrivance. The straw is advanced to receive the operation of the knife, by passing between fluted rollers, as in the former description. As, however, these rollers are placed at right angles with the axle of the fly wheel, the connection is effected either by means of an endless screw upon the axle, the worm of which takes into fitting cogs, or by the ingenious application of a spiral groove, which, in a great degree, gets rid of the friction occasioned by the working of the screw.

Corn and Grass Cutting Machines.

We now come to a description of cutting machines, of which but very little is at present known in practice, though, it appears, that considerable attention is now being paid to the subject. A machine that will efficiently represent hand-labour in the harvest-field would be a great boon to the farmer, as in all field operations, despatch, in such a climate as ours, is a matter of great importance; and the last process of maturation is so rapid, that it rarely happens that a farmer can obtain strength enough to cut all his crops at the precise time he would desire, without taking it from other operations which are perhaps of equal importance, especially in a changeable season. These machines, however, are not new. Some fifty years ago a reaping machine was invented by a Mr. Boyce, for which a patent was granted. It appears to have been a frame carried on two wheels *fixed on* a centre axle: this axle revolving with the wheels gave motion, by means of a pair of bevilled wheels, to a vertical axis projecting *before* the carrying wheels, to the bottom of which scythes were fastened: these, revolving at a rapid rate, cut down the opposing corn; but no arrangement seems to have been made for collecting it or laying it in swathes. Another machine, by a Mr. Plucknett, next appeared. This had a circular steel-plate or disc, with a saw-edge, which was driven in the same manner, and was considered to do better work. Mr. Gladstone, of Castle Douglas, Kirkcudbright, shortly afterwards introduced some improvements in the arrangements of the machine, in the shape of a circular table with stout wooden teeth, notched below all round, which was fixed immediately over the cutter and parallel to it. This circular rake held up the corn against the cutting-knife, and then collected it, and laid it on the ground between the wheels in two parallel lines. A small wooden wheel was attached at the back part of the cutting-knife, with which it was in contact; this was covered with emery, and thus always kept the edge sharp. The next attempt was upon quite a different principle; as in this machine, invented by Mr. Salmon, of Woburn, Bedfordshire, the corn was cut by means of shears, with an arrangement attached for collecting the corn and laying it down in rows. About this time the attention of Mr. Smith, of Deanston, was called to the subject, and the result was shortly seen in the shape of a machine, which he tried for the first time in the harvest of 1811. This was on a small scale. The succeeding harvests enabled him to notice and to remedy some of its defects, by which he was induced to have one constructed on a larger scale, which was practically used on his farm. This machine consisted of an axle and two carrying-wheels, in front of which was suspended a hollow drum or cylinder, to which a rapid rotatory movement was communicated when the machine was in motion. The lower edge of the drum was armed with a circular cutting-knife, and the cut corn was laid in a row on either side of the machine. Behind the axle was fixed a pole, to which the horses were attached, the machine being pushed forward by them through the standing corn. About a Scotch acre (five roods) an hour was cut by this machine. In the Highland Society's Journal is an account of a more recent machine, the invention of Mr. Patrick Bell, and which was tried at Gowrie in 1829. The work done was considered quite satisfactory: wheat, beans, and oats are said to have been cut down on uneven ground at the rate of one acre per hour.

We have been thus particular in noting the machines that have been already before the public, as most of those seem to be merely modifications of the same construction. In another machine before the public we see an arrangement similar to that of Mr. Boyce, motion being communicated from the carrying-wheels to a centre axis, to which two scythes, like knives, are attached. Like the original, also, no arrangement is made for laying up the cut corn; we have the cutting-knives of a different shape, and four in number: they are attached to arms to which a rotary movement is communicated, and have an ingenious contrivance for keeping their cutting surfaces always to the standing corn. In this machine, however, a portion of the frame (which is triangular), with a wheel travelling in front, precedes the cutting-knives, and thus would appear likely to impede the machine by pressing down the corn in front of the cutting-knives.

Crushing Machines.

Machines for crushing oil-cake, corn, beans, and linseed, are now in general use in most farm establishments. There are many very excellent ones for either purpose. Those for oil-cake require great strength, and are usually made with two parallel rollers, armed with spikes or teeth of a pyramidal (cams) or curved form, fixed in a strong frame, set in motion by means of cogged wheels and a fly or driving wheel, to which the handle is attached. The distance between the rollers can be regulated so that the cake may be crushed either for sheep or cattle. Crushers of this description are made by Ransom, Wedlake, Barrett, Garrett, and Hornsby.

The crushers for grain and linseed are somewhat different, the rollers being either fluted or quite plain; for beans they are generally fluted. They vary in form, and also in the method of regulating the rollers. In some, also, we find only *one roller* working against either one or two fixed plates in front or behind, which are grooved or fluted like the roller. The advantages resulting from the use of these machines, in the preparation of artificial food for cattle, are of great importance, as not only does the food afford greater nourishment, owing to its divided state and more assimilable condition, but the crushed state of the grain prevents germination, should any of it become mixed with the litter either by accident or by the excretions of the non-ruminating animals, which is too often seen when the whole grain is used. There are also some machines of a similar character for crushing Gorse, and thus rendering it fit for cattle-food. These are well worthy of notice as materially conducing to the use of an indigenous plant, growing luxuriantly on soils which otherwise would be entirely unproductive, and yet containing in itself matter of a highly-nutritious character, and, when prepared by these machines, readily eaten by sheep and cattle.

WEAVING MACHINES.

Cotton Machinery.

The applications of metal manufacture to machines for weaving require that some notice of such machines should have a place in this treatise. Much of the matter following is obtained from the information collected by the reviser of the present work for one of his compilations connected with the Great Exhibition. In every mode of spinning, whether the material be cotton, flax, or wool, the objects to be accomplished are to *straighten and draw out the loose fibres in a regular and continuous line*, and, after reducing them to the requisite *continuity, to twist them into threads.* Previously to the operation of spinning, the cotton is submitted to a process called *carding*, which was formerly effected by hand with *single cards* (combs); they were afterwards made double, but still it was a work performed *by hand*, and the cotton was stripped off the cards in loose rolls, called *cardings* or *slivers;* and the only difference between the slivers produced by the old cards, and those by the present carding-engine, is, that the former were in lengths of only a few inches, while the latter are in lengths of *some hundred yards*. The sliver thus produced has to be rendered considerably more firm before the cotton can be actually submitted to the process of spinning; and this is now generally effected by two or more pairs of rollers placed horizontally, the upper and lower roller in each pair revolving in contact. The sliver being put between the first pair of rollers, is, by their revolution, drawn through and compressed; it is then caught by the second pair of rollers, placed immediately in front, which revolve with three, four, or more times the velocity of the first pair, and which accordingly lengthen the sliver, and reduce its sectional area in the same proportion. The sliver in some modern machines is still passed through other rollers acting precisely on the same principle, and is at length, when properly extended and compressed, attached to a *spindle* and *fly*, the rapid revolutions of which twist it into *a thread*, and at the same time wind it upon *a bobbin*. In order that these rollers may take a proper hold of the cotton to urge it forward, the lower roller is fluted and the upper one covered with leather.

Little more than 70 years since every thread used in the manufacture of *cotton*, *wool*, *worsted*, and *flax*, *throughout the world*, was spun singly by *the fingers* of *the spinners*, with the aid of that *classical* instrument the *domestic spinning-wheel*. In 1764, an *eight-handed* spinster sprung from the genius of Hargreaves, and the "*Jenny*," with still increasing powers, made its way into common use in spite of all opposition. Two years afterwards the more wonderful invention of Arkwright claimed yet higher admiration, as founded on principles of more *extensive application*. Five years later, 1774, the happy thought of combining the principles of these two inventions to produce a third, struck the mind of Crompton, who, by a perfectly original contrivance, effected the union. From 20 spindles this machine was brought, by more finished mechanism, to admit of 100 spindles, and thus to exercise a Briaræan power.

Kelly, of Lanark, relinquished the toilsome method of turning the machine by hand, and yoked it to the strength of a branch of the rapid Clyde. Watt, with the subtler and more potent agency of *steam*, moved an iron arm, that never slackened or tired, which whirls round thousands of spindles in a single room. Finally, to consummate the wonder, Roberts dismissed the spinner, and leaves the machine to its own infallible guidance; so that now-a-days, since 1834, several thousand spindles may be seen in a single room, revolving with inconceivable rapidity, with no hand to urge their progress or to guide their operations, drawing out, twisting, and winding up as many thousand threads, with unfailing precision, indefatigable patience, and strength — a scene as magical to the eye that is not familiarised to it, as the effects have been marvellous in augmenting wealth and population.

By the *carding-machine*, the fibres are *combed* out and *laid parallel* to each other, and the fleece is *compressed* into a *sliver*. This stage of the process shows the cotton in a very beautiful form. A bar, the *doffer*, some four feet long, with combing motion works on the surface of the combing or carding cylinder, which presents the soft fleecy down to an edge of hair-like teeth, sat in leather along the front of the doffer. These teeth touch the down so lightly as only just to raise it off the cylinder, and leave it hanging, like a gossamer curtain, in the air. A rude breath would have been enough to tear the woven veil. At starting, the attendant gathers the whole breadth of four feet, and with a light hand draws it through a small hole, behind which are rollers that capture it, and continue to wind it up as fast as it is generated. The beautiful delicacy of the transparent veil, and its slow lifelike motion, with the elegant curves which it takes as the rollers gather its full breadth within the narrow tube, make this process delightfully interesting.

The sliver is repeatedly *drawn* and *doubled* in the drawing-frame, to straighten the fibres more perfectly, and to equalise the grist.

he *roving-frame* by rollers and spindles produces a se loose thread, which the mule or throstle spins yarn. To make the warp, the twist is transferred *cops* to *bobbins* by the winding-machine, and from ins at the warping-mill to a cylindrical beam. This being taken to the dressing-machine, the warp is , dressed, and wound upon the weaving-beam. The r is then placed in the *power-loom*, and the shuttle g provided with cops of weft, the cloth is woven.

ll qualities of cotton are not fit for undergoing this l and undeviating or unyielding process; but the perfectly the qualities of cotton wool of different ths are understood, the more completely does the nine-maker adapt it to working up every variety of ity. Hence, as the manufacture has advanced, the ess of preparation has been subdivided more and , and the complication of it apparently increased, gh really the process has been simplified and im- ed — brought, in short, more nearly to embrace the le function of physical and intelligent operators.

is impossible, without drawings, to describe ma- ery. We cannot, however, end this notice of cotton ufacture without calling most especial attention to "self-acting mule." The mule is the combination he inventions of Hargreaves and Arkwright, by npton. The mule receives the thread from the ng bobbins, and passes it through rollers to draw it, instead of receiving the thread when spun on bob- , it is built in cops on spindles. Besides these cha- ristics, the mule stretches as well as spins the ad, after a certain quantity has been delivered from roving bobbin through the drawing rollers. To t this, the carriage which carries the cops runs wards and forwards on grooved wheels, on an edge the distance traversed being about 4½ ft., and when it three feet of the drawn roving has been delivered, delivery is stopped, and the remaining 18 inches of on of the carriage is employed in stretching the ad, which by this means is obtained much finer by any other machine as yet invented.

Mules are either hand-mules or self-acting. The head-stock or mechanism of the self-action of the carriage is one of the most remarkable examples of mechanical contrivance in the whole range of manufacturing machinery. When we consider the delicacy of the motions which it has to transmit, the precision in respect of time with which a variety of motions have to begin and end, so as to spin the gossamer threads which it draws and twists, the genius of the man who endowed wheels, pinions, bands, and levers, with the proportions that partake of and communicate motions resembling and even excelling those communicated by skilled hands, we cannot fail to wonder. The name of Roberts is inseparable from the headstock of the mule. Many and some important improvements have been made on Roberts' first headstocks; but the fundamental plan and principles of its arrangement continue the same.

The first mechanical process to which the dressed flax is submitted is heckling, after it has been submitted to the scutching. A scutching-machine, to which we call attention as novel and very important, seeing that it accomplishes the process in about one-seventh of the time taken to perform it manually: as much can be done in a day with these machines of Messrs. Plummer as in a week with the ordinary hand-scutchers.

From the scutcher the flax is put through the heckling process — a process analogous to combing in woollen and worsted manufactures, and to carding in the cotton manufacture; the object of it being to straighten the fibres, and to lay them parallel to each other. Much skill and ingenuity has been expended in the contrivances for perfecting these important machines. The nature of the operation is simple in itself; but it is complicated by the nature of the material to be operated upon, and was, up to a recent period, done entirely by manual labour. The scutched flax fibre submitted to this process separates the *line* or long fibres from the tow or loose short fibre, of a weak staple and of no value for making thread. The machine being unyielding or undeviating in its operations, would destroy a great quantity of the best fibre unless many nice arrangements had been contrived to effect the process so gradually, that the amount of fibre *broken* and *torn* by the machine is now much less than was the case when heckling was done by hand.

The *line*, from the heckling process, is put into the *drawing-machine*, where it is formed into *slivers*. In these machines the heckled line is spread on an endless web, which slowly and gradually presents it to a pair of rollers revolving in contact with each other. From the first pair of rollers the flax passes to a second pair of rollers, which revolve at some 40 or 50 times the speed of the first pair of rollers, and which, therefore, draw it out to 40 or 50 times the original length of the series of "stricks" laid on the endless web. Between these two rollers, however, there comes a concatenation of gills, or iron-toothed combs, through which the fibres are drawn so that their parallelism is maintained; and in order that this may be done without tearing or breaking the line, these gills advance slowly, moving as it were in an endless band. The action of these gills is analogous to the intelligent use of a comb applied to "unkempt hair," by one desirous to comb it out smoothly without pain to the patient, or destruction of the hair.

This process is repeated several times. The slivers are combined with each other, so as to equalize the distribution of the stronger and more delicate filaments.

The slivers from the drawing-frames are fit to undergo the first process of spinning, called

Roving. — The roving-machine for flax is analogous in its functions, and similar in its construction to the same machine in the cotton process, and need not, therefore, be further described here. By successive rovings, the line is at last spun on the

Spinning-frame — into a description of which we cannot enter.

Silk Winding Machine.

The state of the raw silk is in respect of gumminess such, that, in winding it on to bobbins, a traversing motion is given to the glass guides, in order to lay the silk-thread in such a spiral form as shall prevent any two threads touching each other for more than a very short length. The mechanism of this motion is underneath the frame, but is exceedingly neat. From the winding bobbins the silk is put through the cleansing machine, *i. e.*, it is wound on to a second set of bobbins, but in passing from the one to the other it goes between steel *knife-edges*, which strip off all impurities and destroy inequalities.

The quality of the silk fibre has much influence on the degree of success of the cleansing process, or, more correctly speaking, it is only the better qualities of raw silk that can be subjected to this process of cleaning advantageously. Bengals and the coarser qualities are difficult to treat on these machines. From the cleaning, the silk is put on to the

Doubling-frame, where two or three or more threads are laid together prior to throwing or organising. This machine is variously constructed, but the essential conditions it has to fulfil are — first, that the silk may pass off easily, and without entangling, from the delivering bobbins taken from the cleaning-frame; second, that a small and equal degree of tension be applied to all the threads as they pass from the delivering bobbins to the receiving one, so that the compound threads may be perfectly even; and third, that the receiving bobbins cease to revolve as soon as any one of the component threads happens to break, as without such contrivance a thread would be produced of variable thickness, from the casual omission of one or more of the component threads. The contrivances for accomplishing these objects will be understood only by an inspection of the doubling-frames in motion.

The bobbings being thus filled with compound threads, they pass to the

Twisting or *Throwing Machine*, which spins the silk into threads.

Woollen.

From the earliest period of these manufactures to the latter end of the last century, very few, if any, mechanical improvements had taken place. The only change where any took place, being in the increased skill and dexterity of the operator, and in a choice of materials better suited for particular manufactures. The carding and spinning wool for cloth; the combing and spinning for worsted yarn, as also the processes of dying and dressing cloth, in the early part of the reign of George III., were effected by the same means as in the time of Edward III., which were also in all probability similar to those of more ancient times.

In a manufacture which had for so many centuries continued unimproved, it did not appear possible to the manufacturer that any great change for the better could be made. The "practical men," as a certain large class delight to call themselves, were content to believe their process was perfect. But other brains were at work; and, as is very often the case, inventions were made by strangers to the woollen trade, which overthrew the preconceived notions of the "practical men," and which wonderfully improved every part of the woollen manufacture. The inventions of Hargreaves and Arkwright were immediately applied to wool. In 1780 the first spinning-jenny for woollen yarn was erected, and its use became very general in three years afterwards.

For some time considerable difficulty was experienced in clearing the wool from the carders in the carding machinery, and a slight change in the form of the machine was found necessary to prepare the wool for the slubbing bills.

Wool.—The raw wool, as it comes from the "woolstapler," is put through a machine called a "devil," where it is opened and cleaned, in a manner analogous to cotton in the willow.

By the scribbling machine and carding machine the wool is prepared so as to be suitable for being made into "slubbings," analogous to cotton and flax rovings, and the subsequent processes are so analogous to those described for cotton that we need not here repeat them.

Fulling, milling, felting, dressing, and shearing, are the processes which woollen cloth has to undergo in addition to the cloths made of flax, cotton, and silk.

The *Worsted Manufacture* is a particular and very extensive branch of the woollen manufacture. The principal difference is, that, in what is commonly called woollen cloths, a nap or pile is raised so as to hide the threads of which it is composed; whereas, in worsted stuffs, there being no pile, the threads are exposed. In the former also, the shorter wool is employed, and the larger fibres broken down by the "devil" and carding machine, whereas, in the worsted trade, long wools are preferred and the shorter fibres rejected.

In reference to this trade, an important machine has been invented by Donisthorpe. This machine, by a most ingenious arrangement, separates the long from the short fibre. The precision with which it acts, the perfect manner in which it operates, cannot fail to delight the observer.

Wool-combing was long done entirely by hand; but, as early as 1790, Mr. Cartwright attempted to make wool-combing machinery. This machinery has been gradually perfected; and the double wool-combing machine of Donisthorpe seems to leave little to be desired.

Weaving.

By the processes we have described, the raw material of textile fabrics has been brought to the state of yarn or thread. It remains to call attention to the processes by which these threads are converted into cloth or other *woven* fabrics.

In all cases, the thread spun differs in its qualities — as regards the hardness or amount of twist — according as it is intended to compose the longitudinal threads or *warp* of the cloth, or the transverse threads or *weft* of the cloth. The reason for the greater strength given to the warp is, that in the process of weaving it is subject to much more wear and tear than the weft—the process of weaving tending, in fact, to consolidate the weft by beating one thread up against the other.

The Warping Mill.—In the process of the cotton manufacture, before the yarn comes to the warping-machine, it is wound from the cop on to bobbins about four inches long, and about three inches diameter: these bobbins of yarn are then taken to the warping-machine, for the purpose of the threads being laid equally parallel to each other, to make them into a beamed warp, and to facilitate the arrangement of them after being sized and placed in the healds or "heddles" of the loom in weaving. In the old system of preparing the yarn, before its being placed in the loom, a cumbrous machine, called the warping-mill, was used instead of this improved machine of Mr. Kenworthy's, which warping-mill was worked by hand. After the yarn had been made into a balled warp it was then taken to the old kind of sizing-machine, which soaked the yarn into the warm size, then dried it, then squeezed it between iron rollers, and next it was reballed. The warp was then taken from this machine to a machine for winding it on a roller-beam, after which it was taken to the looming-frame, and next to the loom to be woven into cloth. But now, by the connection of Mr. Kenworthy's warping-machine with the sizing-machine of Messrs. Hornby and Kenworthy, the process is made much shorter and more simple, and is withal systematic and mechanical.

The bobbins containing yarn are placed in a wooden frame called a "creel," so that they will revolve; the threads are then passed through a "wraithe" on to a roller-beam. The "wraithe" is for the purpose of keeping the threads separate and uniformly in the order in which they are intended to be wound off (after having passed through the size) on to the weaver's yarn-beam. In this machine is a beautiful adaptation of mechanism, by which the yarn may be backed off the beam, if by chance any broken thread has escaped the eye of the operative and got on the beam. This motion consists of a series of small cylindrical rods, so arranged that the threads of yarn pass under them; and supposing none of the threads to break during the process, the beam would get filled without any necessity for calling this invention into action. But it so happens that breakages often do occur, and, as the machine works at a rather quick speed, those dissevered threads get on to the beam before the operative has sufficient time to stop the machine. The machine is provided with two sets of driving pulleys, one pair at each end of the driving-shaft: that pair which drive the backing-off motion work one-half the speed the others do. The leathern straps or bands which connect these pulleys with the main shaft of the factory are so arranged by the one (that which drives the backing-off motion) being crossed and the other being open, that the motion of the machine can be reversed whenever the threads are broken; the operative, therefore, effects the stoppage of the machine by simply passing the open strap off the fast pulley to one revolving loosely on the shaft; he then reverses the motion by passing the crossed strap off a loosely revolving pulley on to the fast pulley, thereby turning back or backing off the threads from the beam. The series of cylindrical rollers then perform their office by moving down slots made in the framing of the machine, in their progress bearing down with them the threads backed off the beam, until the severed thread is discovered and united, when the operative sets on the machine as before the breaking took place, and the cylindrical rollers return to their former position. After the beam is filled by this machine, it is placed, along with five others, in the improved sizing-machine. These beams are placed in bearings so that they will revolve at the left end of the machine, and weights are placed upon their pivots, so that they are kept in their places; the six threads of yarn are then passed through an ordinary comb-bar or "wraithe," and thus divided equally until passed through the healds, which, in this machine, are situated at the left end, for the purpose of effecting the cross shed, and thereby taking the "lease" previously to the yarns being submitted to the sizing process. The "lease" now being taken, and the cross band or threads being introduced for the purpose of "looming," or drawing in of the weaver's beam, the threads of yarn are passed over a "wraithe" or comb-bar, formed by a row of teeth or pins of intervening spaces, for the purpose of laying the threads in parallel breadths side by side, and forming each division or band of threads (of any required number) into separate and distinct tapes or sheets (of any desired width), each thread being laid parallel side by side, and thus in lateral contact, the "wraithe" or comb-bar being allowed to vibrate or oscillate freely as the threads proceed. The continuous threads being thus made or separated into breadths or bands, are now passed over a conducting roller, and immersed into the trough containing the sizing material, which is here kept in a heated state by steam passing through a pipe into the trough, and thus boiled into the warp-threads as they pass through it and under the adjustable tension roller, which can be adjusted to any required degree of tension at pleasure, or can be raised up, when necessary, entirely out of the trough by means of a winch, worm, and rack, with which the pinions of the rollers are connected. The threads are then passed forward through a pair of squeezing rollers, and again similarly immersed in the trough containing the size, to finish the yarn; from thence they are passed around the drying cylinder, also heated by steam, and now assume the form of tapes or bands, the sizing material, by its slightly adhesive properties, causing the threads thus to adhere slightly together, and thus proceed in a tape-like form, being of course much stronger, more regular and even, and less likely to be broken or disarranged than in the old mode of sizing. A circular revolving brush is placed over the threads as they proceed over the drying cylinders, for the purpose of dressing or laying the fibres, and making the tapes or bands more compact and even. They now proceed in a sized, dried, and finished state, being conducted by two rollers through a similar "wraithe" or comb-bar, but of a much finer pitch, and by passing through which the bands of threads are passed edgewise, and again similarly divided by the oscillating or vibratory action of the comb-bar, and laid over the tension roller at the right-hand end of the machine, in a proper state to be received and wound upon the warp-beam, ready for the operation of drawing in, after which operation it is taken to the loom and woven.

An improved self-acting marking apparatus is connected with this machine. Upon the end of one of the revolving guide-rollers of the machine, a small worm works into a wheel on the end of a shaft, at the reverse end of which is a little mitre wheel driving a corresponding wheel upon another shaft, which carries at its other end a revolving marker, which marker alternately dips into a box of colour, and marking the warp threads therewith as it revolves, it thus marks out any desired length of warp for the pieces of cloth intended to be woven, and allowing the warp-beams to contain accurate lengths without waste in the looming. The combination, therefore, of the division of the threads into bands, the arrangement of the "healds" for obtaining the cross shed in taking the "lease" previous to dressing or sizing, the new forms of "waithes" or comb-bars, and the self-acting marker, with the improved construction of the mechanism employed, constitutes an important improvement, and is of great benefit in the preparation of yarns for weaving.

The warp in the state last described is received by the *weaver*.

We cannot do more in this treatise than state that the numerous power-looms now employed, the Jacquard looms, the machines for making the *healds* or heddles,— for making reeds, for cutting cards, and for making other appendages to weaving machinery, — weaving indeed in almost every fibre, — cotton, flax, silk, worsted, and wool,—are directly dependent upon the ingenuity of our engineers in metal manufacture. We are constrained to relinquish giving an account of the variety of looms and loom mountings, which the ingenuity of our manufacturers has introduced for these various kinds of weaving. Any description of their peculiarities would exceed the entire limit of the present volume.

The power-loom is one of the most remarkable machines of the age we live in.

Mr. Harrison exhibited at the Great Exhibition a power-loom made in 1798 or 1800, alongside of the most improved looms of the present date. How great the difference! Yet the honour due to Robert Miller, who introduced power-looms of the same construction as this old loom in 1796, is perhaps greater than to those who have produced the improvements, because his was the *beginning*.

The old machine can be worked to advantage at 60 picks per minute, requiring one person to each loom, or five persons to six looms. The new looms can be driven at 220 picks per minute, and were to be seen working at that speed in the Exhibition, and may be inspected in all the best power-loom mills in England and Scotland.

One person can attend two of these, and in many instances three looms.

An experienced operative of the manufacturing district, working the modern looms, produces 26 pieces of printing cloth, 25 inches wide, 29 yards long, and 11 picks per $\frac{1}{4}$ inch, in a week of 60 hours. The cost of weaving each piece is 5$\frac{1}{8}$*d.*—less than 6*d.*! If the same cloth were woven on the old loom, one operative would produce only four pieces, and at a cost of 2*s.* 9*d.* each; or the weaver's wages in 1800 were as much as is the entire value of the *cloth* in the Manchester market at present. Wonderful mechanical result! What are the moral results?

Rope-making Machine.

Rope-making is an art of very ancient date. The fibres commonly employed for the purpose are hemp or flax.

The first part of the process of rope-making is spi ning the yarns. This is done either by hand in t rope-walk — familiar to all — or by machinery, ar a logous to the flax-spinning machinery already me n tioned.

The next part of the process is warping the ya ns, or arranging them so that they are stretched so a to be of uniform lengths when laid together. *Yarns* are laid into *strands*, and *strands* are laid into *ropes*.

The main points in the art of rope-making are the laying the fibres together with only that angle of lay, or amount of *twist*, as it is termed, which is necessary for greatest strength; and the laying the yarns together into strands, so as to insure the greatest uniformity of strain on each yarn. That is, so as to insure the greatest uniformity in the length of the yarns composing the strands.

Till the end of last century these points were very imperfectly attended to, and, consequently, only very inferior ropes were made.

We can only allude to the efforts at improvement made by Sylvester, in 1783; by Cartwright, in 1792; by Fothergill, in 1793; by Balfour, in the same year, whose improvements nearly approached the root of the evil. Balfour distinctly understood that before a rope is brought to its breaking strain, the strands composing it are much elongated, and their diameters reduced. Now, under any reduction of diameter, the outside coat of yarns must slacken considerably, and can give therefore little or no support to the internal yarns, which, from the comparatively great length of their lay, or smallness of their spiral, could elongate but little, and must of course break in succession from the centre outwards. But Balfour's improvements only tended to alleviate these defects; and the mode of operation was so complex and laborious as to prevent its adoption.

Capt. Joseph Huddart patented, in 1793, "A new mode or art of making great cables and other cordage, so as to attain a greater degree of strength therein, by a more equal distribution of strain upon the yarns." Huddart's machinery, modified since originally patented, s still in very general use. It produces ropes of a very ood quality, though there are inherent imperfections. t requires the use of a rope-walk.

Huddart's machinery went further than Balfour's towards regulating the lay of the yarns so as to insure quality of strain. Huddart perfected Balfour's next rocess by giving to the mass of the yarns, thus formed nto strands, an additional twist, by which the strand was shortened, and provision made for the effects above nentioned as resulting from a reduction of diameter on he rope being stretched.

The first machine designed for rendering rope grounds r walks unnecessary, seems to have been that of W. Chapman of Newcastle, in 1797. Chapman's second atent was for "laying, twisting, or making ropes and trands of ropes; and for coiling up such ropes and trands of ropes during the process of making." This nachine involved nearly all the principles to be seen n the rope machinery now in use, which if seen at vork, affords a clear insight into the usual process of naking hemp ropes by machinery without "a walk." The art of rope-making seems, however, to be still open o much improvement, if we start from the fundamental rinciples above laid down.

In the machinery generally, the yarn reels do *not* urn on their own axis; the yarns are, therefore, untwisted as they are formed into strands. The strands re laid into ropes, and the ropes are coiled away by the ombined motion of the machine.

The specimens of ropes imported from Havre and Rouen, and from Katwyk, in Holland, are worthy of speial study by those interested in the use of hemp ropes.

Ropes are made white or tarred.

Flat ropes are made by sewing several round ropes ogether, and have been much used for mining puroses.

Ropes are made of all sizes, from fine cords, t
of twenty-five inches in circumference ; but si
adoption of chain cables in the navy, and of wir
in almost all cases where strength and durability
importance, the use of larger sizes of hemp ro
been very limited, and confined to the standing ri
of ships.

CHAP. XII.

LOCKS.

EARLY FAME OF WOLVERHAMPTON LOCKS.—AINGER'S DISCOURSE ON LOCKS. — EGYPTIAN LOCK. — BARRON'S PATENT. — BRAMAH'S PATENT. — PRINCIPLES OF BRAMAH'S LOCK EXPLAINED. — CHUBB'S PATENT LOCK. — DURABILITY AND SECURITY OF CHUBB'S LOCK.—IRON SAFE LOCKS.—KEMP'S LOCK.—STRUTT'S LOCK.—NOTICE OF INGENIOUS CONTRIVANCES FOR LOCKS. — MARQUESS OF WORCESTER'S ENIGMATICAL DESCRIPTION. — ANDREW'S LOCK. — NEWELL'S LOCK.—KEYS FOR LOCKS. — DOOR LATCHES.

UNTIL the invention of the steam-engine, and the introduction of that wonderful and complex variety of machinery for spinning and weaving, which has almost every where followed the masterpiece of human ingenuity, the lock used to be spoken of as exhibiting, in its most intricate construction, the highest perfection of smithery. It would be difficult to point out the period when, in this country, the lock first became known; and as the best means of securing property from unlawful or violent access must always have engaged the attention of those who held the patronage of the mechanic arts in their hands, it cannot be doubted but that the fabrication of locks, more or less complex, would at least accompany, even if it did not precede, in this country, the manufacture of arms. It does not, indeed, appear that any of our more early illuminated manuscripts contain the representations of locks, though keys are sometimes found to occur of a form not differing greatly from those commonly in use.

Until within a late period, the general lock trade flourished almost exclusively at Wolverhampton; which place, in the more economical and less curious articles, still shares the patronage of the country with Birmingham and London. This celebrity was acknowledged two or three centuries ago; and Dr. Plott, in his History of Staffordshire, particularly notices it. "The greatest excellency of the blacksmiths' profession that he could hear of in this county lay in their making locks for doors, wherein the artisans of Wolverhampton seem to be preferred to all others; they making them in suits, six, eight, or more in a suit, according as they are bespoke, in such a manner that the keys shall neither of them open each other's lock, yet one master-key shall open them all. Hence, these locks being placed upon separate doors, and the inferior keys kept by distinct servants, though neither of them can come at each other's charge, yet the master can come at them all. Moreover, the master, by turning his key in any one of the servants' locks but once extraordinary, can prevent the servants themselves from coming at their charge. Neither shall the servant spoil his key or lock in making the attempt. Nay, they can so construct locks, that a master or mistress can tell how often it has been opened or shut, even during a whole year together. These locks they make either in brass or iron boxes, so curiously polished, and the keys so finely wrought, as not to be exceeded."

About four years ago, a very interesting discourse was delivered at one of the evening meetings of the Royal Institution, by Mr. Ainger, on "the principle of security in the various kinds of locks." According to an outline of this discourse, published in the Quarterly Journal of Science, this gentleman considered the means of giving security to locks to be of two sorts: the first consisting in numerous obstacles, commonly called wards, placed in the direction of the passage of the key, and therefore requiring a peculiar form of bit to avoid them; the second consisting in a number of impediments to the motion of the bolt,— these impediments being so contrived, that their absolute and relative positions must be changed before the bolt can be withdrawn.

Means of the first class are considered defective, because a surreptitious instrument need not thread the mazes of the obstacles or wards: it escapes them by taking a path on the outside of them, which is unavoidably left for a passage for the extremity of the key: complexity in the form of the wards does not, or but very slightly, increase the security, when a picklock is introduced; neither does it generally add to the difficulty of imitating the key, because, in most keys of this sort, nearly two thirds of the metal is superfluous, and requires not to be copied.

According to Mr. Ainger, means of the second sort are the most ancient, having been known in Egypt above 4000 years, as was inferred by M. Denon, from some sculptures on the great temple at Karnac, representing locks similar to those now used in that country, in which means of that sort are employed. The bolt and fixed part of the lock are each pierced with any number of holes, arranged in any chosen form,—those in the bolt and in the fixed part coinciding when the bolt is locked. These holes are occupied by pins, which are contained in the fixed part, and descend into the bolt, so as to prevent its motion till they are wholly removed into the fixed part. This is effected by a key, having the same number and arrangement of pegs, and of such length that they elevate the ends of the pins in the lock to the place of motion between the bolt and the fixed part. The key is introduced laterally through a long tube, at the end of which it acts vertically upon the pins, whose position, therefore, it is difficult to ascertain.

This principle of security was not generally known in this country, or in Europe, till it was re-invented by Mr. Barron, and applied by him in conjunction with wards to the security of a lock, for which he obtained a patent in 1774. The same principle was afterwards adopted by Mr. Bramah, without the assistance of wards or obstacles to the key; but the mode of application was very different from the Egyptian. In the latter, the security arose from the number and position of the impediments; in Mr. Bramah's, these are discoverable on inspection, and the security depends on the various degrees of motion which the several impediments require before the bolt can be moved.

These gradual improvements in the fabrication of locks introduced a corresponding degree of attention to the art of picking, which would have been fatal to the reputation of the new locks, had it not been for the almost simultaneous invention of a very simple and cheap alteration, by which the required position of the impediments is rendered undiscoverable.

It was in or about the year 1784, that this new principle was introduced into the art of constructing locks by Mr. Bramah, of Piccadilly,—a name which has subsequently become so identified with the mechanical improvements of our age. Mr. Bramah secured his invention by a patent; and, in a sort of prefatory record attached to the specification, he alludes to the principles of the common locks in use, and then explains the theory of his own. The means previously adopted for the security of all locks are stated to have been, the inserting or fixing, between the keyhole and the bolt, a greater or less number of wheels or wards, which said wheels or wards may be crossed or interwoven in such a manner as to render the communication between the keyhole and the bolt as crooked and irregular as possible, in order to prevent the bolt from being moved by any counterfeit application when the proper key is absent; the bit of which key is so cut or shaped as to form a complete tally with the interior machinery, and be thereby capable of producing the desired effect when applied for the purpose of moving the bolt. According to Mr. Bramah, the insufficiency of this method of rendering locks a perfect security is as follows; viz. notwithstanding the arrangement of these wheels and wards may be so extensively diversified, yet they cannot by any means be sufficiently variable to answer the intended purpose, owing to their being always left fixed in the lock. Their form and disposition can, in almost all cases, be easily obtained by impression; so that, notwithstanding they may prevent the exercise of picklocks yet the making a skeleton or surreptitious key is always extremely practicable. And, besides, the variations capable of being made in the disposition of such wheels or wards, and in the form of the key's bit, are not sufficient to produce the required number of locks, without having large quantities exactly alike, and their keys capable of opening one another reciprocally; in consequence of which they become a very imperfect security against violation, as any ill-disposed person might, by furnishing himself with a number of old keys, be enabled to open almost all the common locks in the kingdom with as little difficulty as if he had in his possession the key belonging to each lock.

To remedy these objections by the application of some principle or method whereby the success of picklocks, false keys, and all other counterfeit means of opening locks, might be infallibly prevented, constitutes the claim of Mr. Bramah. In this discovery, the old complication of wards and wheels is done away, and instead thereof, a greater or a less number of movable parts, such as levers, slides, &c., are adapted so as to require each of them a separate and distinct change in their situation and position before the bolt, and other parts of the lock on which its safety depends, can be set at liberty or moved. In the language of the inventor, "these said levers, sliders, or other movables, by the assistance of an elastic, gravitating, or other power, have the property of maintaining or restoring their given position or situation after it may have been destroyed by any forcible application for that purpose. From this said property, the said levers, sliders, or other movables, are rendered capable of receiving (as it were) any impression or required change in their position or situation, correspondent to the cause which produces such said change, and are also thereby always restored to their former state or resting situation, when the said cause is withdrawn, so that the opening of these locks is as difficult as it would be to determine what kind of impression had been made in any fluid, when the cause of such impression was wholly unknown; or to determine the separate magnitudes of any given number of unequal substances, without being permitted to see them; or to counterfeit the tally of a banker's check, without having either part in possession."

Mr. Bramah proceeds: — "The form of these levers, sliders, or other movables, and also the manner of fixing them in the lock, may be varied without end, without altering or losing any of the intended properties or advantages; as the principal merits and efficacy of the invention do no ways depend thereon, but entirely depend on the levers, sliders, &c. being so fixed or disposed as to prevent the bolt, or other parts of the lock on which its safety depends, from being moved, without the said levers, sliders, or other movables first receiving, each of them, a separate and distinct change in their position or situation, by a key or other contrivance for that purpose, which, being pushed against them in a progressive direction, without revolution, occasions them to change their positions in a manner exactly correspondent to the part of the key so applied. And the said part, being formed with a number of irregular surfaces, equal to the number of levers, sliders, &c. against which it is pushed, causes them to move at different times and to different distances from their original situation. And this key, by having a stop or mark to determine the length of its push against the levers, sliders, &c., puts a period to each of their motions, notwithstanding they are at liberty to move farther, but are prevented by the resistance of a spring, gravity, or other power, always endeavouring to restore them to their original situation; so that the motion of each lever, &c. separately depends on the height or depth of the surface of the key against which it falls. Hence a perfect tally is formed, similar to any impression made in a soft body by the forcible application of any harder one; which hard body represents the essential part of the key, and may be of any determinate shape, formed by rule or by accident; and the moving of the bolt, or other parts of the lock whereby it may be opened, entirely depends on the positive motion of the levers, &c., as any one of them would, by being pushed the least degree too much or too little, entirely prevent the bolt, &c. from being moved or set at liberty. And as the whole of the said levers, sliders, &c. are restored to their resting situation when the key is withdrawn, by the properties or powers above mentioned, the tally or impression is then totally destroyed, and, consequently, the opening of the lock is then left wholly dependent on chance, whilst the said key is absent; as there is no rule whatever, nor imagination founded on certainty, that may, in the least degree, tend to assist in discovering the required position or situation of each or any of the said levers, sliders, or other movables, whereby the form of the key necessary to the opening of the lock might be ascertained.

"Now, admitting," continues the ingenious describer, "that no lock on this principle can be picked, or the form of the key obtained, their farther security then depends on the number of different keys that may be made without having any two of them alike; which number, I trust, will appear indeterminate from the following demonstration, viz.: — Let us suppose the number of levers, sliders, or other movables, by which the lock is kept shut, to consist of twelve, all of which must receive a different and distinct change in their position or situation by the application of the key, and each of them likewise capable of receiving more or less than its due, either of which would be sufficient to prevent the intended effect: it remains, therefore, to estimate the number producible, which may be thus attempted: — Let the denominations of these levers, &c. be represented by twelve arithmetical progressionals; we find that the ultimate number of changes that may be made in their place or situation is 479,001,500; and by adding one more to that number of levers, &c., they would then be capable of receiving a number of changes equal to 6,227,019,500, and so on progressively, by the addition of others in like manner, to infinity. From this it appears, that one lock, consisting of thirteen of the above-mentioned levers, sliders, or other movable parts, may (by changing their places only, without any difference in motion or size) be made to require the said immense number of keys, by which the lock could only be opened under all its variations."

The specifications and drawings in the Patent Office, illustrative of this ingenious and useful discovery, have been published: the following is their substance:—

Fig. 88. is a machine designed to show the nature and design of Mr. Bramah's invention. G represents a sliding bar or bolt, in the frame K, that hath cut in its edge six notches of any proper depth. In these notches are placed six slides, or small bars, A B C D E F, that are sunk into the bottom of each notch, so that the motion of the bar or bolt G is thereby totally prevented till these sliders are moved some way or other to give it liberty; which must be done from their ends at I I, as no other part of them is meant to be exposed for the purpose of moving them; which ends, at I I, always have an equal projection when the bar G is set fast. Now, supposing each of these sliders capable of being pushed upwards towards A B, &c. to any determined distance, and when each of them has exactly received its due motion, the bar G is set at liberty, so as to slide backwards and forwards as required; and, in order to determine the separate and distinct motion that shall be given to each, we will suppose the part H to be made; which part serves to represent a key, and the ends, 1, 2, 3, 4, 5, 6, are cut of different lengths, either by rule or by chance, so that, when pushed against the ends of the sliders at I I, they will cause each of them to be slided up at different times, and to different distances from I I, in a form exactly corresponding with the ends of the part H: thus, by forming a complete tally, the bar G will have liberty to be slided backward and forward without obstruction; and when brought into its original situation, and the part H withdrawn, the slides A B C D,

c. will then fall down into their notches, and fasten as usual; their ends at I I being perfectly restored

Fig. 88.

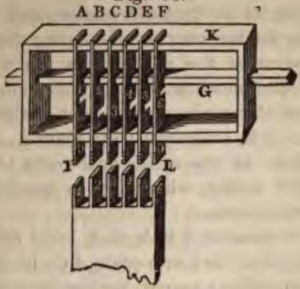


Fig. 89.

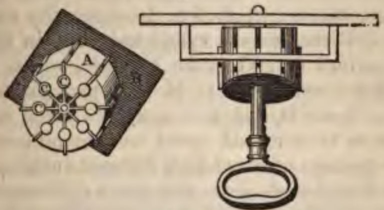
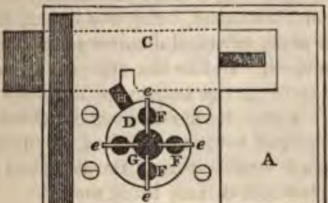


Fig. 90.



en as before, not the least of the position required in em to set the bolt at liberty remaining.

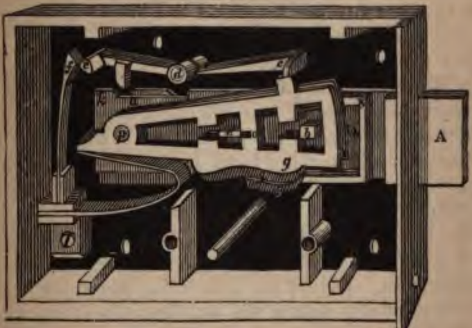
Fig. 89. represents the manner in which sliders may applied to locks of all sorts. A is a frame or barrel that moves the bolt by its turning, in which barrel or frame are fixed eight, or any other given number of sliders. B is a thin plate fixed in the lock, through which the barrel or frame A passes, and is prevented from turning for the purpose of moving the bolt, by the projecting parts of the sliders that move in the fixed plate B, till the notches in each of them are, by the application of the correspondent part of the key, pushed into contact, or in a line with the plate A. At the end of each slider, in the cylindrical parts C C C, &c. is fixed a spiral spring, which always restores them after the key is withdrawn.

Fig. 90. represents a lock that locks on both sides. B is the bolt; C is the lower plate, in which the projecting part of the sliders moves, for the purpose of securing the bolt; *e e*, &c. are the sliders; D is the barrel or frame represented in *fig.* 89., in which the sliders are fixed; F F, &c. are the cylindrical parts in which the spiral springs act; G is the key-hole, which is bored through the centre of D; H is a part joined to the barrel or frame D, and acts as a key's bit to move the bolts when D is turned round for that purpose. The end of the key is formed with different surfaces, which, as before explained, gives the sliders different motions, and brings the notches in them, when pushed down to its stop on the shank, exactly into a line with the cover plate C; which notches, being the size of the thickness of the said plate, permit the barrel D to make a revolution, if required. But as the sliders may each of them be pushed as far as the bottom of the slit or groove in which they move, so the notches in them are liable, with an improper key, to be pushed too far or too little, both of which would prevent the barrel D from being turned, or the bolt B from being moved.

Having given the foregoing ample description of the principle upon which this ingenious lock is constructed, it will be proper to describe another celebrated invention, well known to the public as Chubb's Detector lock. Of these two famous lock securities, it may not, perhaps, be irrelevant to observe, that they are equally capable of being manufactured of any size, and, consequently, they are found attached to elegant and portable articles, such as jewel-cases, ladies' albums, and reticules, as well as to strong fixed doors, coffers, &c. The first patent for this detector lock was granted in 1818, to Jeremiah Chubb, of Portsea, Hants; and in 1824, Charles Chubb obtained a patent for a plan of applying the regulating bolt in such manner, that the proper key which is used to work the lock may also perform the office of relieving the detector, when it has been lifted out of order by any surreptitious access.

There can be no doubt but that the construction and arrangement of the parts in Chubb's invention do combine in a very high degree the four principal requisites of a good lock, viz. security, simplicity, strength, and durability. The first, particularly, is increased beyond calculation by a contrivance which not only renders it impossible to be picked or opened by any false instrument, but also detects the first attempt to open it,—thereby preventing those repeated efforts to which even the best locks are sometimes exposed.

Fig. 91.

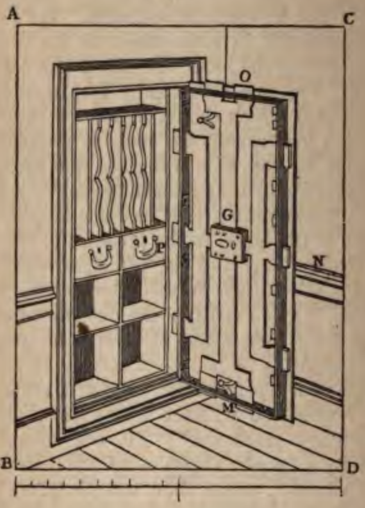


A A *a* the bolt; *b* the square pin of the bolt; *c c* the detector, moving on the centre *d*; *f* the detector spring; *g* four tumblers moving separately on a centre, and shown lifted by the key to the exact position for the square pin *b* of the bolt to pass in unlocking. Should one or more of the tumblers be lifted by a pick or false key in the least degree beyond their present position, the detector *c c*, being thus overlifted, will, by the angle of the spring *f* pressing on the opposite side of the angle of the detector, force its hook into the notch *a* of the bolt, and be firmly held so, until disengaged by the regulating slide K *k*; in which case, by the introduction of the key, the tumblers are lifted to the regulating combination, and admit the stud *n*, affixed to the regulating slide, to enter the several grooves *o* in them; the bevelled end *k* of this slide by the same movement pressing against the hook of the detector, disengages it from the notch *a* of the bolt.

It has been found that the durability of Mr. Chubb's lock is fully equal to its security: to test it on this point, a rather singular expedient was resorted to at an early period of its history. An iron-rim lock was attached to a steam engine in the dock-yard at Portsmouth, by which method the bolt was shot backwards and forwards upwards of 460,000 times; and yet, notwithstanding this amazing trial and friction, the lock was not in the least injured.

The patentee having, by order of the honourable Navy Board, supplied a number of locks for the use of Portsmouth dock-yard, was informed that there was a convict on board one of the prison ships at the port, who was notorious for picking locks, having been for several years engaged in making and picking locks in London. Mr. Chubb requested the favour of the honourable sir George Grey to send for this man, that he might exercise his skill in attempting to pick one of the patent detector locks. One of the locks being presented to the inspection of the man at the storekeeper's office, after a careful examination he said he thought he could pick or open it with false instruments. He was therefore furnished with files, and such other tools as he thought necessary to prepare his instruments for that purpose; and, in order to stimulate his industry and ingenuity, five pounds were promised to him if he succeeded. In about three weeks he sent word that he was ready to make the experiment. A time being fixed, he commenced operations by endeavouring to pick one of the locks, in the presence of the principal officers of the dock-yard; but he could not succeed. He then stated that his failure was in consequence of his instruments not exactly fitting the lock. To afford him a still fuller opportunity, the patentee actually furnished him with some blank keys which should fit two of the locks, together with a lock exactly the same in principle and in kind as those he had been trying, so that he might examine its construction, and make himself master of its principle. Shortly afterwards he made another attempt to pick two of the locks, in the presence of the honourable sir George Grey and the principal officers of the dock-yard. His success in this attempt was not better than before, for he overlifted the detector of each lock. Sir George Grey then asked him, what he would do in this case, supposing he had been making an attempt on such a lock with the intent to commit a robbery. He said,—"I would go no more to the lock; they would set a watch and catch me." He still thought, however, that by a further alteration of the instruments he could yet succeed: more time was therefore allowed, and every facility afforded. Some time afterwards he again repeated his efforts, in the presence of the same gentlemen; but having, in his previous experiments, overlifted the detectors, he could not by any means disengage them. This was done for him several times with the keys belonging to the locks; but as often as they were regulated, on every successive trial he detected them again; till at last he gave up the attempt, saying, "that he had used his utmost ability in his repeated attempts, and could not succeed: that these locks were the most secure he had ever met with; and that he did not think it possible for any man to pick or open them with any false instruments whatever." A mos signal instance of the failure of an attempt made by a ingenious and confident locksmith, to pick or in an manner open one of Chubb's locks, occurred in a s trial of skill at Wolverhampton, in 1832.

Fig. 92.

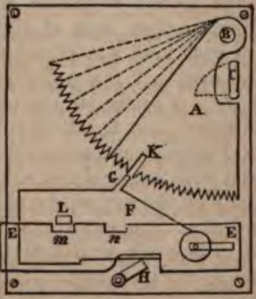


The annexed engraving represents the lock of an iron safe, which is built about with masonry. It will be perceived that the bolts connected with the lock G, in the centre, contain ten stout pieces, projecting in the direction of the letters M N O P. These bolts may be thrown and withdrawn, either by means of a loose key or a stationary handle on the outside of the door; the locking of them in the centre, and upon which the security depends, being performed by another key. The cut here referred to was made from one of Chubb's locks; but Bramah's, or those on any principle considered inviolable, are applied in the same way, and for similar purposes. The springs under the bolt heads M and O are for the purpose of assisting the vertical lift of the pieces, which are of considerable weight. In very large locks, such as are affixed to bankers' coffers, and are sometimes five or six feet high, and three or four feet wide, or even larger still, the bolts, which are proportionally ponderous, are made to move upon friction wheels: they are worked either by levers, or by racks and pinions, the motion itself being secured by a separate lock, as in the cut.

Mr. Kemp, of Cork, published, in 1816, a lock, the interior security of which consists in the adaptation of tumblers or sliders; but these are operated upon by means of a contrivance, consisting of two, three, or more little tubes, one within the other, and of different lengths, placed inside the barrel of the key. These tubes, being made of determinate length, depress or push back the pins or sliders that detain the bolt to the required positions, until each one corresponds with the notch that is cut in it for the projecting part of the bolt. Mr. Kemp calls his invention the Union lock, from the circumstance that it unites the qualities of the approved locks of Barron and Bramah; and from the manner in which the combination is effected, it affords, according to the inventor, "a greater degree of security than either of the former, or than both of them together, supposing a lock of each kind was placed on the same door." He further asserts, "that a dishonest servant, who does not possess any particular ingenuity, may be instructed by a locksmith how to take the requisite impressions of either Bramah's or Barron's keys, even if he could be intrusted with them only for a few minutes: this cannot be done with the key of the union lock; it would require the locksmith to examine it himself, and make several tools to ascertain its different dimensions, which he could not do without having it in his possession some considerable time, with leisure to make repeated trials."

The sketch (*fig.* 93.) represents a lock, invented in 1819, by a Derbyshire gentleman of the name of Strutt. The principle of this ingenious but simple contrivance consists in a number of quadrant levers, which are acted upon by the key near the centre of their motion: on their circular edge they have notches, which allow the bolt to be shot when these notches correspond. These plates or levers may either be made to return to their places by a spring, or fall by their own weight when that is sufficient. By this means a small movement of the key produces a large one of the serrated arc: hence considerable space is obtained for the false notches, as well as for the working ones, to be brought into action by different keys, when requisite; which keys, as belonging to different locks, do not at all resemble one another. This allows of key, sub-master key, and grand-master key. One peculiar difference between Mr. Strutt's lock and those commonly in use is, that in the latter the key passes the wards, or puts them into the proper positions, and also moves the bolt; in the lock now under description the key is only required to put the levers into the right position, and the bolt is moved by the hand through the agency of a fixed knob or handle, as in the common door catch. A (*fig.* 93.) represents a thin plate or quadrant lever of iron, brass, or other con-

Fig. 93.



venient material, of which there may be any number lying upon or parallel to each other, according to the security required. These plates or levers may, as already stated, either be made to return to their places by springs, or fall by their own weight where that is sufficient. B is a centre pin, upon which they all turn. C shows the keyhole, and the dotted line the extent to which the key is moved. The key is made with steps or notches, so that, when it is introduced, these notches act in turn upon the different levers, and raise them to different heights, some more and some less. E E is the bolt; F the tumbler; G a sharp-edged piece fast to the tumbler, which, if raised, would press against the edges of all the levers or plates; H a wince, acted upon by a handle. Now, when the key is introduced, and turned as far as is shown by the dotted line, and all the levers put into new situations, the tumbler F is attempted to be raised, and where the edges of the levers or plates are marked by the piece G, a nick is cut in every plate or lever K. It will be evident that the tumbler F can then be raised, and be allowed to enter the nicks in the plates. Turning the handle, and wince or button H, raises the tumbler F, and shoots the bolt. The bolt is kept in its place by the pin or knob L, fixed into F, falling into the notches *m* or *n*. The circular edge of every plate is filled with small serratures, something like saw teeth, which prevents any person, who may attempt to pick the lock, from knowing whether or not he has moved any of the plates or levers, till one of the deep acting notches, or one of the serratures, which are placed only to mislead, are opposite to G. A lock on the principle of Mr. Strutt's invention, as altered and improved by Walters, is in considerable credit.

A few years ago, a Mr. Duce, of Wolverhampton, received the silver Vulcan medal of the Society of Arts, for a lock for an iron safe, which throws out four bolts in different directions: it is, in fact, a combination of four distinct locks opening by the same key: the chief advantage of this arrangement is, that whatever time is required to pick a single lock will be quadrupled in the picking of this, so that while one bolt remains fixed the door will be safe. Chubb's lock is admirably adapted for the fastening of vertical iron doors by means of heavy diverging bolts: whatever may be the weight or dimensions of the door, four bolts of a corresponding strength are made to traverse it from the lock in the centre; these bolts are at once shot out or withdrawn by means of an outer knob attached to a pinion wheel within the lock, the actual key being very small and portable.

There have been a variety of other contrivances at one time or other introduced to public notice, either promising additional security, or more generally direct means for ascertaining attempts at violation; such as Mr. Lawson's sliding curtain, by which the keyhole is so perfectly closed during the act of unlocking, that it would be impossible to move the bolt while a pick remained in the aperture: Mr. Gottlieb's project for placing a piece of paper at the back of the lock, and immediately over the plate covering the works; by which means a false key introduced would perforate the paper, and thus lead to the detection of any surreptitious attempt to move the bolt of the lock. More particularly may be mentioned those locks exhibiting combinations of letters or figures engraved upon rings or other movable pieces, acting upon tallies within, and the proper arrangement of which, so as to admit of the bolt being moved, is only known to the party owning the key, or those to whom the secret may be intrusted. Locks have been made, which require that the key should be a powerful magnet; others, in which an unusual and complicated motion must be given to the key, or in which an improper key would fire a pistol or ring an alarum.

At a late meeting of the Society of Civil Engineers, a model was exhibited of an improvement for giving security to locks principally intended for bankers' safes, but which might be used in many other ways — such as for the safe conveyance of valuable parcels in coaches. The principal feature of this improvement is the adaptation of a common eight-day or other clock to the inside of the safe or box, secured by a lock in the usual manner. The interior of the safe is fitted up with a strong iron catch, which, upon locking it, drops into a notch made in the bolt to receive it. Until the catch is lifted, the bolt cannot be drawn, nor the safe opened. By a mechanical arrangement, the clock inside the safe elevates the catch at any hour previously determined on, and until the arrival of that hour no key can open the lock. Most of these expedients, as Mr. Ainger justly observes, are more curious than useful; there being no difficulty in making a lock perfectly inviolable; and nearly every one of those of any estimation now before the public are, when well made, quite secure.

In that singular tract, entitled "A Century of Inventions," written by the marquess of Worcester, and which has frequently been reprinted, there are notices of three or four different kinds of locks; these notices, however, have the same character of pedantic and enigmatical obscurity which envelopes every one of the articles throughout the entire hundred.

"69. A way how a little triangle screwed key, not weighing a shilling, shall be capable and strong enough to bolt and unbolt, round about a great chest, an hundred bolts through fifty staples, two in each, with a direct contrary motion, and as many more from both sides and ends, and at the self-same time shall fasten it to the place beyond a man's natural strength to take it away; and in one and the same turn both locketh and openeth it.

"70. A key, with a rose-turning pipe, and two roses, pierced endwise through the bit thereof, with several handsomely contrived wards which may likewise do the same effects.

"71. A key perfectly square, with a screw turning within it, and more conceited than any of the rest, and no heavier than the triangle screwed key, and doth the same effects.

"72. An escutcheon to be placed before any of these locks, with these properties: —

"1. The owner (though a woman) may with her delicate hand vary the ways of coming to open the lock ten millions of times, beyond the knowledge of the smith that made it, or of me who invented it.

"2. If a stranger open it, it setteth an alarm agoing, which the stranger cannot stop from running out; and besides, though none should be within hearing, yet it catcheth his hand as a trap doth a fox; and though far from maiming him, yet it leaveth such a mark behind it as will discover him if suspected; the escutcheon or lock plainly showing what money he had taken out of the box, to a farthing, and how many times opened since the owner had been in it."

In the "Mechanics' Magazine" for 1827, there is a letter from "A Country Correspondent," the writer of which says, that he has invented a lock similar to that described by the marquess of Worcester, and also an escutcheon, either of which will bid defiance to the ingenuity of man to open by any means but with the proper key. We have been favoured with a sight of this very ingenious lock, which, as it is intended to be made the subject of a patent, we cannot with propriety more explicitly mention, than to say, that in combination with as much strength as it is possible to give to any lock, it does in its principle of security realise the most important of the above conditions of the paradoxical marquess, — being, in fact, equally impregnable to the smith who shall make it, and to the individual who has invented it; and even were each to have the proper key in possession by accident or stratagem, it would be of no use.

The workmanship of many first-rate locks equals, in perfection and finish, the security of the principles upon which they are constructed; the keys likewise are not only in most cases much reduced in weight, but they are at the same time often beautifully finished; and this, in those of no great price or rarity. A very great improvement, as facilitating the formation of the key out of a bar of iron, has been introduced within the last twenty or thirty years. Formerly the shank was first drawn out of the heated rod upon the anvil; then the bit was formed by the hammer; and, lastly, after a hole had been punched through the metal in a substance left for that purpose, the bow was beaten out with considerable labour and care upon a beaked anvil, exactly in the same manner as scissor bows are still forged. At present, however, the key is only very partially moulded with the hammer upon the anvil; after which the iron is properly heated, and placed in a die under a powerful stamp, which with one stroke forms the bow, the shank, and the bit of the key; in which state it is ready for filing, boring, and turning. In the larger and more fanciful descriptions of keys, the bits are commonly soldered to the barrel. While the bit remains unfinished, the key is called a blank, and sold for a small price; and it is from these blanks that the country locksmiths generally make keys, either to suit their own locks, or to replace others that may be broken or lost; and in some cases, knowingly or unknowingly, for more equivocal purposes, when a key is sometimes adapted or imitated in an inconceivably short time. It was stated, during an investigation of the robbery of the betting rooms at Doncaster, some years since, that a gentleman, taking with him the key of his portmanteau, got a duplicate made by a locksmith in eight minutes! Upon reference to an act of parliament it will be seen, that to make a key by any other way than from the lock, and then delivering it at the residence of a housekeeper, subjects the party to a fine and imprisonment.

Since the Great Exhibition, attention has been called to the question of locks by the fame of Mr. Hobbs, who succeeded in picking both the Chubb and Bramah locks. The Society of Arts offered a prize for a lock, and that of Mr. Denison appears particularly deserving attention.

In the locks submitted by Mr. E. B. Denison to the

Society of Arts in compliance with their premium list, "for the invention of a good and cheap lock, combining strength and great security from fraudulent attempts; cheapness, freedom from disarrangement by dirt, and requiring only a small key," it will be evident from inspection, that both the tumblers and the "stump" of the bolt have greater strength and means of resistance to force, than in other locks of the same size, while the key of this lock, which is suitable for safes of the largest size, and capable of shooting any number of bolts, only weighs one third of an ounce.

The smallness of this key in proportion to the size of the lock is not obtained, as in some other safe locks, by diminishing the size and strength of the tumblers, but by giving the key nothing to do except raising the tumblers without the resistance of springs. The bolt is shot by the handle, and the lock thereby secured without the use of the key, which is only required to raise the tumblers to such a position as to enable the lock to be again opened by means of the handle. While in the class of safe locks above referred to, the ultimate security is only that due to the strength and security of a small lock which is locked into the main bolt by a key made after it is shot by the handle. By way of security against drilling a false keyhole into the lock, there may be a thick case-hardened, or chilled cast-iron, plate placed between the lock and the front of the door.

In these locks the tumblers are merely short lengths of hoop iron, and both the tumblers and the friction plates between them are left as they come from the roller, and not likely to be disarranged by dust or dirt. Friction, instead of being, as in other tumbler locks, a thing to be counteracted as far as practicable, is in these locks an advantage, as it assists in keeping the tumblers steady in whatever position they are required to assume either by the key or the handle; and for this purpose one or more of the separating plates is slightly bent to make them always act as friction springs on the tumblers.

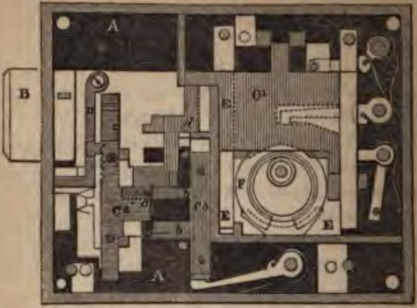
In the ordinary tumbler locks, if a drop of thick oil or other substance should get between the tumbler and its adjacent tumbler or plate, it frequently overcomes the power of the spring to depress the tumblers, and the lock then comes to a "dead lock," there being no means of introducing a substitute for the spring to bring down the sticking tumbler; or should a spring get broken, which occasionally happens where they are allowed to get rusty, the same result takes place; whereas in these locks there are no tumbler springs, and there is always the power of the handle to bring down the tumblers. It may also be observed that the curtain having no opening in it, keeps the keyhole closed against dirt and the corroding effects of a damp or smoky atmosphere.

Amongst other locks which have acquired some celebrity, may be named Jenning's permutation locks. The principle of these consist in a series of rotatory permutation discs or plates, unaided by springs or tumblers, which, in locking, may be changed millions of different ways, at the option of the owner; thereby destroying any knowledge previously obtained of the interior arrangements, and preventing the use of false keys or pick-locks.

In America the progress of lockmaking has been highly creditable. Up to a dozen years ago it was then generally thought that the system of lock with tumblers or slides could not be picked, and that no false keys would be available, the form of which could be derived by any knowledge gathered from examination through the keyhole. The only risk, therefore, it was conceived, was treachery or dishonesty on the part of the maker, or on the part of persons who had access to the key, and could take an impression.

This defect was, however, considered formidable enough to render a change necessary, and it was, therefore, the endeavour of the locksmiths of the States to make a lock which the owner could change at will, and so produce a new arrangement which should be unknown to any one but himself.

Fig. 93 *a.*



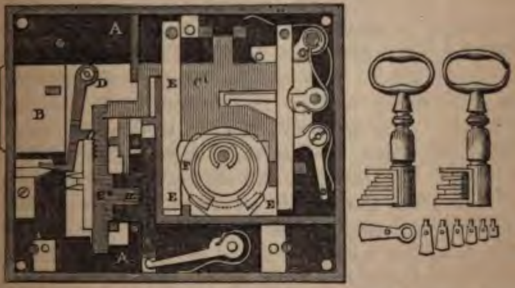
The first successful lock of this kind was the invention of Mr. Andrews, of Perth Amboy, New Jersey (*fig.* 93 *a.*) His lock had Chubb's tumblers and detector; but, before fixing, the owner could alter his tumblers as he pleased, the key having moveable bits, which he could alter to suit the new arrangement of the tumblers.

To alter the combination without displacing the lock, each tumbler could, in the act of locking, be either raised or drawn out with the bolt. Rings corresponding with the thickness of the moveable bits of the key were supplied to the purchaser, and any of the bits could be displaced and a ring or rings substituted. The rings, therefore, took the place of the bits, and the corresponding tumblers were not lifted on turning the key, but would be drawn out with the bolt (acting, indeed, as part of the bolt). So much of the security, therefore, as was due to an increased number of tumblers was lost, and half the bits and acting tumblers would give only a proportion of the security. The point sought for was that, if a tumbler drawn out with the bolt be raised in picking, or should any of the tumblers be lifted beyond their assigned limit, the detector would act, and the bolt could not be drawn back. This lock was highly esteemed in America, and used in most places requiring security; and Andrews offered a large reward to any one who could pick it.

The success of Andrews drew forth competition, and, among others, Mr. Newell brought out what he called his "permutating lock," (*fig.* 93 *b.*) the novelty of which was, that it had a double set of tumblers, the first being acted upon by the key, and the second by the first set or series. A screw, called "a clamp-screw," passed through the second set, and a clamp overlapped the tumblers inside, each tumbler having a slot moving over the clamp-screw. This lock had also a small round hole directly over and communicating with the head of the screw. This formed the recess for a small auxiliary key, so that when the large key gave the desired arrangement to the tumblers, the auxiliary key was used to act on the clamp-screw, thus holding the second series by compression, and retaining them in the positions imparted by the ordinary key; the door was then shut, the bolt locked, and the first series fell to their original position.

The defects of Newell's first lock, thus described, were, that the use of an auxiliary key was inconvenient;

Fig. 93 *b.*



and, if the clamp-screw were not released every time the door was unlocked, the first series of tumblers would be held by the second, and, consequently, an impression could be obtained through the keyhole while the lock was unlocked.

Mr. Newell then introduced another device, which was, that upon each of the second set of tumblers he made a series of notches corresponding altogether with the extreme range of the belts, so that if there were four bits there would be four notches, and so for any other number. On turning the key each bit raised its tumbler, so that some one of its notches presented itself opposite a tooth, on a dog or lever. As the bolt was moved, the teeth entered the opposite notches, and the second set of tumblers were held in place by the dog or lever. This dispensed with the auxiliary key. On unlocking, the tooth was lifted out of the notch, and the tumblers fell into their first position, the lock becoming a blank.

It occurred to Mr. Newell some years after he had introduced his second lock that he could pick Andrews's lock, and he accordingly did so by a very simple instrument. He next found that a somewhat similar instrument would pick his own lock, and from these experiments he established, and very frankly announced, the fact that all locks on the tumbler principle were insecure.

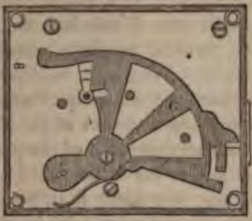
Having upset the reputation of his own and other existing locks, he next turned his attention to the probability of producing a "*non-pickable*" lock, and, after one or two failures, he produced one which he conceived safe. This was by notching the abutting parts or stump face of the primary and secondary tumblers. The tumblers could not, therefore, be raised sufficiently, held fast as they were by the "false notches." For some time this improvement was deemed to have given the desired security, until an engineer named Pettis said he could pick the lock. The inventor thereupon put one up for a trial of skill, with an offer of a reward of a sum equal to one hundred guineas to any one that picked it. Pettis picked the lock and pocketed the reward. Newell then, with admirable perseverance, tried again, and produced the creditable specimen which is in the Exhibition, under the title of the parautoptic * permutating lock, and which has excited so much interest by the contest between Mr. Chubb and Mr. Hobbs, the proprietor of the patents, on the question of the practicability of picking Chubb's well-known lock.

The following is a description of the exhibited lock:—

Fig. 93 b. represents the lock unlocked, with the cap or top plate removed. *Fig. 93 a.* shows it locked. *Fig. 93 c.* is the lock with the cap on, showing the detector-tumbler.

A A, *fig. 93. a,* represents the case of the lock; B, the bolt; C C, the moveable slides or tumblers. On that portion of the tumbler marked C 2 are a series of notches, corresponding in distance with the difference in the lengths of the moveable bits of the key. As the key is turned in the lock to lock it, each bit raises its tumbler, so that some one of the notches presents itself in front of the tooth on the dog or lever, D. As the bolt is projected it carries with it that portion of the tumbler C 2, and presses the tooth into the notches, withdrawing the tongue, *a*, from between the jaws, *b b* and allowing the portions of the tumbler C 1 and C 3 to fall to their original position; while the part C 2 is held in the position given to it by the key, by means of the tooth being pressed into the several notches (as will be seen in *fig. 93 b.*). Should an attempt be made to withdraw the bolt with anything but the true key, the tongues *a* will abut against the jaws *b*; and, should an

Fig. 93 c.



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* "Parautoptic," *i.e.* concealed from the eye.

attempt be made to ascertain which tumbler binds and requires to be moved, the portion of the tumbler C 3 that takes the pressure being in front of the wall, E, E, E, prevents the possibility of its being reached through the keyhole while the parts of the tumbler C 1 are detached at the point marked *d*, thereby making it impossible to ascertain the position of the parts in the front chamber. F is a revolving ring or curtain, which prevents the inspection of the interior of the lock; and, should the ring be turned to bring the opening upwards, the detector-tumbler, G, on the cap of lock (*fig.* 93 *c*), is immediately carried over the keyhole, effectually closing it on the outside.

The great peculiarity of this lock is, that it changes itself to the key, so that, whatever arrangement of bits is adopted on the key, the lock modifies itself to that arrangement without the necessity of meddling with the lock itself, or removing any part of it. The buyer can, therefore, alter the arrangement of the parts at will, and according to the law of permutation.

It will, therefore, be evident that, by altering the numerical arrangement of the bits, the lock becomes a new lock, *secure against any but the key which locked it.* On turning the key each tumbler is raised according to the length of the bit, imparting to the two sets of tumblers the precise form of the key. The second series, being projected with the bolt, and the tooth on the lever or dog being pressed into the series of notches on the face of the second series, holds them in their places as given them by the key, while the other parts fall again into their places. Should pressure be put on the bolt to ascertain the obstruction, such pressure will evidently be exerted on the third or intermediate tumblers. To prevent access to these, a plate or wall of metal extends round the key-chambers in a rectangular form, so that an operator can only make his attacks on the key-chamber. The possibility of his finding what interferes with his picking is prevented by the part of the tumbler which takes the pressure given by him to the bolt being detached from the parts which can be got at through the keyhole. The secret arrangement is, therefore, enclosed in a steel box, accessible only through one well-filled aperture, and which forms, in fact, the only opening to this inner or insulated lock.

One method of picking pre-existing locks was to blacken the under side of the tumblers by a smoky flame. The key would then leave legible marks on the tumblers the next time it was used, and the extent of the marks would exhibit the length of the bits. To see this a small mirror hinged to the end of a wire was introduced into the keyhole, and the exact length of each bit was ascertained by measuring the distance from the centre of the keyhole to where the soot was abraded from each of the tumblers. By these measurements a key capable of opening the lock could be made. An electric light from a pocket battery was used to show the interior when necessary.

It will be manifest, however, that no such process could be adopted to guide any one in attempting to tamper with Newell's invention; nor is there, as far as we see, any other mode of opening it except by the legitimate key, or by the destruction of the lock.

Of the same class of manufactures, and almost invariably accompanying the door-lock in use, — often, indeed, enclosed in the same box, — is the latch. It is made in a variety of ways: either as a simple lever, lifted by means of a thumb-bit, when it is provincially called a sneck; or acting with a spring, and having brass knobs upon a spindle, as is most commonly seen on inner doors; or, lastly, lifted by means of a key, as in the well-known French latch. The last named contrivance, on account of its cheapness, its usefulness, and its easy operation—a simple vertical lift—has obtained almost universal approbation as a convenient substitute for the more expensive locks. But notwithstanding that every latch has its appropriate key, the simplicity of the principle precludes all chance of that variety in the cutting of the bits, which is required to prevent the possibility of nefarious copying or substitution. More secure, but more complex, follows the combination latch of Chubb. The improvements in the construction of these latches consist in combining two, three, four, or more distinct movable latches, placed side by side, or one behind the other, moving independently of each other on one centre pin, and shutting into or behind a double catch, so that the combined latches cannot be unfastened unless every one of them is lifted by the key or handle to one precise position; for in that position alone can the latches be disengaged, so as to withdraw them from the double-hooked catch; because, if any one of them is lifted too high, or not high enough, that one latch will be held behind one or the other of the hooked catches, in a sufficient manner to secure the door, even though all the other latches should be properly placed, so as to offer no impediment to unfastening.

CHAP. XIII.

WEIGHING MACHINES.

ANTIQUITY OF THE BALANCE. — PRINCIPLE OF THE EQUAL-ARMED BALANCE. — FRAUDULENT BALANCES. — PROPERTIES OF A GOOD BALANCE. — COUNT RUMFORD'S BALANCE. — DIRECTIONS FOR MAKING A GOOD PAIR OF SCALES. — BALANCE AFFECTED BY HEAT. — THE STEELYARD. — BRADY'S DOMESTIC WEIGHING SCALE. — SPRING STEELYARD. — DIAL WEIGHING MACHINES. — COUNTER WEIGHING MACHINE. — LARGE PLATFORM MACHINE FOR WEIGHING LOADED VEHICLES. — OLD ENGLISH WEIGHTS. — TROY AND AVOIRDUPOIS POUND. — STANDARD WEIGHTS. — PARLIAMENTARY INSTRUCTIONS FOR RESTORING THE STANDARD WEIGHTS.

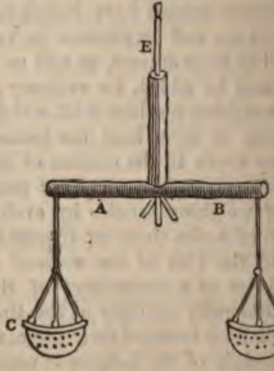
CONTRIVANCES for ascertaining the relative amount of ponderable substances generally, by poising an unknown against a known weight, are of great antiquity, and in their approaches towards perfection have exhibited those varieties of form and that diversity of principle, which we might naturally enough have looked for in articles of such universal use and importance in every civilised community. The most ancient, as well as the most obvious, and, it may be added, for ordinary purposes the most perfect, weighing machine with which we are acquainted, appears to have been the balance or scales, constructed very much in the manner of those in common use among our shopkeepers at the present day, for the purpose of weighing articles by avoirdupois. To this description of scales there are frequent allusions in the Bible; and the idea of the zodiacal Libra shows that the knowledge of a contrivance of this kind was familiar to astronomers so early as the time when the celestial constellations received their present names. Although the principle of the balance is perhaps the least adapted for weighing false of any other in common use, without subjecting the fraud to detection, it is nevertheless certain, that false weights and false balances are as old as the art of weighing itself.

The manufacture of weighing machines is carried on in this country to an extent and perfection commensurate with the amount and precision of our dealings with foreigners, as well as with one another, and likewise in consistency with those perfect methods of operation which characterise our workmanship in metals, and our knowledge of the calculation and application of mechanical forces.

The equal-armed balance, so commonly seen in this country, is an exemplification of what writers on mechanics usually denominate a lever of the first kind, the point of suspension in the middle of the beam being the fulcrum; consequently equal weights act with equal momenta at both ends. The subjoined cut exhibits the figure of a rude pair of scales, copied from the margin of an Anglo-Saxon MS. by Mr. Strutt.

Suppose A B a stick or rod of metal twelve inches in length, and C D two basins of copper suspended from

Fig. 94.



the opposite ends of the rod by chains or strings; while E is another string, tied so exactly in the middle of the rod or beam, that when the whole is poised, the said rod A B and the scales C and D hang in horizontal lines, and, of course, parallel to each other. Now, if two pieces of lead, or any other substance perfectly equal in size and density, be placed one in each scale, the equipoise will remain just the same as it was before; or if one of these pieces be removed,—say that from C,—and its place supplied by equal weight of any other substance of greater or less specific gravity, the bulk will, by this means, be materially diminished or increased in relation to the size of the weight in D, but the equiponderance of the scales may remain unaffected.

The scales being in the position described, it will be obvious, that if any portion of ponderable matter be taken from or added to the contents of scale C, such alteration should be indicated by the proportionate rising or falling of the opposite scale; but then the degree of nicety with which such variation will be indicated will depend upon the delicacy with which the balance is constructed, especially in those parts upon which the movement depends. Suspended by a string, as we have supposed the beam in this case to be, particularly if that string should be of considerable thickness, it is evident that a palpable alteration might be made in the contents of either scale, before that alteration would be indicated by any corresponding inclination of the beam; because, before any such effect could take place, the cause thereof must not only be sufficient to overcome the *vis inertiæ* of the beam in a state of rest, and even the friction of so much of the string as passed underneath, but likewise of the contact of the string with both sides of the beam, which, in proportion to its thickness, would cause the suspending cord to act with a certain leverage against sensible oscillation.

It is an easy matter, however, in the manufacture of scales for ordinary uses, so to suspend the beam upon an axis, and the chains which support the basins upon the extremities of the beam, that the friction shall be very trifling as compared with the amount of the article weighed. All these points, however, may be carefully attended to, and still the weighing may be deceitful. For instance,—

Balances used in commerce are sometimes constructed, either fraudulently or by inaccurate workmanship, so as to make unequal weights produce equilibrium. This effect is produced by making the arms of the balance, though apparently equal, really unequal. In this case, the weight suspended from the longer arm will balance a greater weight suspended from the shorter arm, and the proportion of the weights which will thus balance each other will always be the same as the proportional length of the arms of the balance. Suppose the longer arm is expressed by the number 51, and the shorter by the number 50; then a weight of fifty ounces suspended from the longer arm will exactly balance a weight of fifty-one ounces suspended from the shorter arm. When such a balance is used in commerce for the purposes of fraud by the seller, he will put the article to be weighed in the scale attached to the longer arm, and the weights or counterpoise in the scale attached to the shorter arm: the weight indicated will then be one ounce in every fifty-one ounces greater than the true weight of the commodity: but if it be used by a fraudulent buyer, he will, on the contrary, suspend the commodity which he is about to buy from the shorter arm, and the counterpoising weights from the longer arm; in which case fifty-one ounces of the commodity bought will appear to weigh only fifty ounces. It will be readily perceived that the more unequal the arms of the balance are, the more unequal will be the real and apparent weight of the commodity, and therefore the greater the extent of the fraud.

The detection of a fraudulent balance of this description, than which nothing is more easy, depends on the fact, that if two weights produce equilibrium when placed in the dishes, the equilibrium will be destroyed if they are transposed. Thus, when the commodity to be weighed, placed in one dish, is balanced by weights placed in the other, let the community be removed to the dish in which the weights are placed, and the weights to the dish in which the commodity is placed. If the balance be fraudulent, the equilibrium will be no longer maintained; and on the other hand, if the equilibrium continue, it may be inferred that the balance is a just one.

When a common balance is purchased for domestic purposes, it should always be tested as follows:—Let a weight be put in one dish, and balanced by weights in the other dish; let the weights be then transposed, and if the equilibrium be not preserved, the balance is incorrect and useless.

In the formation of a good balance there are three things to be especially attended to: the fulcrum or prop which sustains the beam; the points of suspension on which the dishes or scales rest; and the centre of gravity of the beam. In a delicate balance, two triangular prisms of hardened steel are attached to the centre of the beam, so that when the beam is placed in the horizontal position these pieces present an acute angle downwards: these knife-edges, as they are called, rest on plates of hard steel or agate, which are inserted in the stand which sustains the balance. Now, suppose a line drawn in the horizontal direction through the point of this knife-edge: this line must pass through two other knife-edges formed of hardened steel presented upwards. On these edges the scales or cups are suspended, so that in a strict sense the arms of the balance are the distances from the centre knife-edge to the edges which form the points of suspension: these distances should therefore be made accurately equal; and a provision is accordingly made in some balances, by which one of the points of suspension may be moved towards or from the centre, so as to render the arms equal, if they should happen to be unequal.

The centre of gravity of the beam, when unloaded and in the horizontal position, should be perpendicularly below the knife-edge on which the beam rests. If it were above that edge, the beam would evidently have a tendency to overset, since the centre of gravity would endeavour to attain the lowest possible position. If the centre of gravity coincided with the knife-edge, the beam, when unloaded, or loaded with equal weights, would rest in equilibrium in any position whatever, and therefore the horizontal position would cease to be an indication of the equality of the weights.

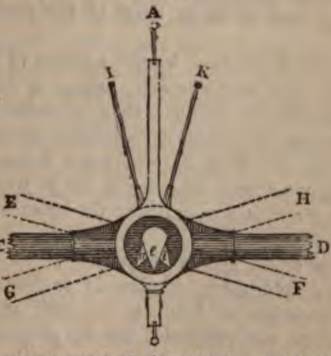
The distance of the centre of gravity below the knife-edge must depend on the degree of sensibility which is required in the balance. If a great degree of sensibility is required, the centre of gravity must be very near the knife-edge, in which case a very small difference of weights will deflect the beam from the horizontal position. In this case, however, the process of weighing is generally tedious, owing to the slow vibrations of the beam; and for the coarser purposes of commerce, it is found more convenient to place the centre of gravity at a greater distance below the knife-edge.

As an illustration of the extreme nicety which has been attained in the manufacture of balances for philosophical purposes, count Rumford, in the detail of his experiments on heat, mentions that the scales used by himself in the determination of very minute quantities would indicate a difference of weight amounting to no more than $\frac{1}{700,000}$th part of the weight of the matter under investigation, which was less than half a pound; and the parliamentary commission lately intrusted with the investigation of the legal standards of weights and measures profess to have ascertained the amount of the old Troy pound, as weighed against a certain quantity of distilled water, to a nicety equal to the 458,000th part of a grain.

Desaguliers, who investigated the properties of the lever, has left some directions for making a very exact pair of scales. Few of the scale makers, it seems, of his day, knew in what the nicety of a balance consists: they generally followed a fashion, or, when they would excel, endeavoured to outdo one another in ornaments, or a fine polish, consulting beauty more than use; and thinking the business well done if they brought the balance to turn with a small part of a grain. A special fault, of which, in the opinion of the philosopher, some scale makers were guilty, was making the arms slightly unequal, and then, to hide the defect, they adjusted the balance by filing away some of the thickness of the longest part of the beam, and sometimes even adjusting the weights of the scales so as to produce the apparent equipoise. Others, again, by making ornaments in a nice balance, sometimes weaken a slender beam, just under the axis, where it ought to be strongest.

The axis of the beam should be made of good steel, carefully formed so as to unite strength with delicacy: its section is sometimes, in large scales, that of a rhombus, but more commonly of the figure in the ring below: it must also be hardened and polished to a fine edge, but not left so sharp as to cut. The two rings, or bearers, at the extremity of the fork in which the axis rests, and by means of which the beam is suspended, should likewise be made very smooth, and of hardened steel. Their form is also material: if circular, as represented in the lower part of the profile of the suspending fork A (*fig.* 95.), which is the common form, and if the planes of the rings are exactly

Fig. 95.



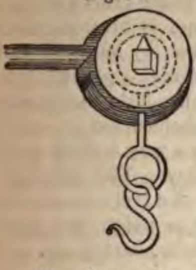
parallel, the axis, of which *e* is the section, resting accurately at the bottom of the rings, and being in a right line with the common centre, the scales, if otherwise well made, will weigh right, the beam resting in the horizontal position C D; but if, as must frequently happen, especially when the rings are large, the edge of the axis rest a little on either side, as indicated by the sections *a i*, by so much the beam will be thrown more or less into the positions indicated by the dotted lines E F or G H, and the inclination of the examen I, K, will show that the equilibrium of the scales is proportionately disturbed. To lessen the inconvenience arising from this cause, it has been proposed to make these rings so that the lower part should be a narrow oval, in which the axis may rest.

The beam, having been made with so much accuracy that it will hang perfectly level when not weighted, is next to be fitted with the basins and their appendages. Each of these being furnished with its hook, and strings or chains, must be weighed singly in another pair of scales, care being taken to weigh each of them in the same scale against the counterpoise in the other scale, without shaking the beam to alter the position of the axis, should it lie in rings of the form first described.

When the beam does, by the position of its examen or vertical spur over the axis, appear to have its two brachia exactly *in equilibrio*, then, in order to ascertain whether or not the points of expansion are exactly equidistant from the axis, the scales are hung on; and if they hang equal, and continue to do so when changed for one another, it is a sign that the balance is properly adjusted.

In large scales generally, as well as in the smaller sorts when sold cheap, the boards or basins are suspended by means of hooks to the ends of the beam, which is bent and perforated for the purpose: some of the very large beams have their ropes or chains attached so as to depend upon an axis at each end similar to that in the middle, only having its edge upwards. All the better kinds of light balances — as those used by the grocers, for example — are constructed with what are called by the makers *box-end* beams: one of these boxes is represented in the margin.

Fig. 96.

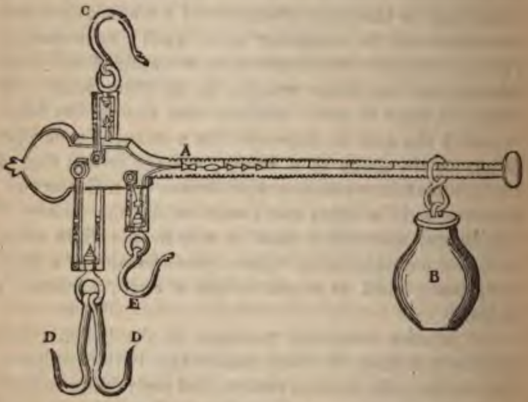


A square bit of steel passes through the box, being filed away in the middle until it present an edge like that of the axis of the beam: this sustains and allows free play to the ring within the box, to which, by means of the hook, the scales are suspended. The side of the box next the eye is supposed to be removed to exhibit the axis and ring — the latter indicated by the dotted circles.

The effect of heat in expanding iron is well known: any very partial alteration in the temperature of a delicate scale-beam is therefore productive of a sensible deviation from accuracy in weighing under such circumstances. Place a sovereign, for instance, in one scale of a delicate balance, and the proper weights in the other scale; the money is light weight: but hold that arm of the beam to which the gold is suspended for a moment over a jet of gas or the flame of a candle, and the heated side of the balance will presently preponderate. Mr. Gutteridge, conservator of weights and measures for the county of Middlesex, mentions a case in which this slight cause produced a decided effect upon a pair of scales of a large size, being such as would weigh *a stone, horseman's weight.*

Of inferior antiquity, perhaps, to the balance, but still the invention of a very remote age, is the steelyard, derived from the Roman statera, and resembling in form the little instrument in use amongst the Chinese, called the dotchins. The steelyard, which is so well known in most parts of the world where weighing is practised, is mostly used in this country for ascertaining the amount of large and heavy matters, such as hay and corn: it is, in fact, an unequally armed balance; and as the difficulty of ascertaining the accuracy of its operation is considerable, and the temptation to use it fraudulently great, its use is properly restricted to those occasions and those articles where great nicety is not required. Its liability to abuse is greatest when used, as is not unfrequently the case, by butchers and others, to weigh commodities promptly to passing customers; because, when poised in the hand, the indications of weight are not only easily misrepresented, but the leverage of the beam is so peculiar that a very trifling trick may make it an engine of dishonesty. The chief recommendations of the steelyard are, that it occupies much less room than a pair of scales to weigh the same amount would occupy; and especially, having but one weight, its application is convenient, nor is it so liable to be mislaid as its fractional parts would be.

Fig. 97·



The annexed figure represents a steelyard manufactured by Mr. Day of Birmingham, and adapted to weigh from 1 lb. to 400 lbs.

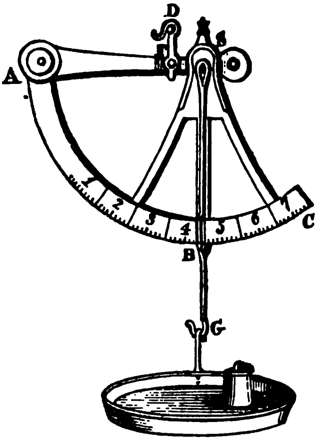
A is the beam or lever, of the smallest size, being 14 inches in length from the end of the bar to the axis, and capable of weighing 66 lbs. The divisions on its upper and lower edges indicate single pounds, and the cross lines tens—from 15 lbs. to 66 lbs. in the present position of the beam. The movable weight B weighs 2½ lbs. The steelyard is suspended by the hook C; and D D are hooks upon which the article to be weighed is placed. When it is intended to weigh any commodity under 15 lbs., the beam is inverted, the hooks D D hang beside C, and E becomes the poising hook; the other side of the beam being, of course, figured from unity to 14 lbs. It will be seen that the centres of suspension in this steelyard, instead of being in a right line, as in those commonly known in the northern counties under the designation of drones, are so placed, that, either edge upwards, the beam partakes somewhat of the tendency of what is called a *douce* balance. One alleged advantage of this construction is, that when the ball is moved to the notch in which it equipoises the substance depending from the hooks, there is no occasion to support it with the hand, as the cock or pointer, which makes a right angle with the beam, will stand upright when the weighing is accurate.

It will be obvious, that if, instead of the hooks D D, and the ball B, scales were suspended from the axis of the former, and from another axis in the situation of the latter, loose weights might be used of a much smaller size than would be required to counterpoise any given article in an equal-armed balance; and hence scales are constructed on this principle in order to save trouble in large weighings, as, with a proper beam, 56 lbs. suspended to the longer brachium, will balance 4 cwt. upon the shorter, and so on to one ton or upwards, the weight being graduated accordingly. A steelyard of this description, with the basin suspended by chains, was found among the ruins of Pompeii. It is figured and described, with other similar articles, by sir W. Gell; and from a date on the beam in Roman numerals, and the words "exacta in capito," it appears to have been made, or at least marked, in the 77th year of our era, and to have been proved in the capital of the empire. Some of the balances found were accompanied by the *ligula*, or small weight which slides along the beam.

An ingenious and useful application of the principle of the steelyard is exhibited in the instrument invented in 1816, by Mr. Brady of Lambeth, and called by him the Domestic Balance, from its being more particularly adapted for family purposes, such as weighing meat, bread, butter, &c., having a self-acting weight, which is part of the machine. It is contended, that this balance is preferable to the common scale with loose weights, the latter being often lost or misplaced by servants or children. The common steelyard is not convenient for domestic use, having no scale or dish to place the goods in; nor is it always sufficiently accurate to detect short weight in small articles, which Brady's balance will do. It may be made to estimate any amount of weight, and takes up very little room in a kitchen or other place, as it hangs flat against the wall when not in use. It is not very liable to be damaged or to get out of repair, and is always ready when wanted.

This instrument is represented in *fig*. 98. It consists of a graduated metallic limb, A B C, connected with the centre S by three strong metal radii or spokes. The whole is suspended from a fixed point D by a hook. The edge on which the instrument rests at F is at a short distance from the centre of gravity on the radius A S. On an edge near the centre S is placed an edge presented upwards, on which rests a loop of metal terminating in a hook at G. To this hook the scale, or the substance to be weighed, is suspended. When the instrument is unloaded, the arm A F preponderates, and the graduated arch passes through the loop, until the *index* on the edge of the loop is opposite zero. Every additional weight appended to the hook G pulls down the arm F S, and causes a part of the arch to pass

Fig. 98.



through the loop,—the point at which the index rests always indicating the amount of weight.

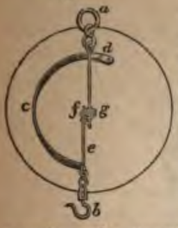
Of late years, several ingenious and useful contrivances for weighing have been introduced to the notice of the public, depending upon the well known principle of extreme elasticity in nicely tempered steel.

The most portable, though not the most satisfactory, weighing machine of this class, is that so long known under the appellation of the spring steelyard. It consists of a small tube of brass or iron, enclosing a steel spring coiled about a rod of iron, which rod, passing through a hole in the bottom of the tube, is finished with a hook upon which to hang the commodity to be weighed; and immediately above is a graduated scale serving to indicate the weight suspended. The iron rod is attached to the steel spring, which is drawn down or allowed to recoil, according to the force applied; the marks on the scale indicating, by their appearance outside the orifice, the weight of the article placed upon the hook.

Among the various improvements in machines upon this principle may be mentioned Salter's, which has a brass plate affixed, with a groove down the middle, in which a pointer slides, to indicate, by a reference to side figures, the weight of whatever may be appended to the hook; and the index-weighing machine, invented by Mr. Martin, to whom the silver Isis medal of the Society of Arts was presented. This machine is composed, in front, of a circular dial-plate of brass, traversed by a hand or index, like the minute hand of a clock: the axis of this hand is a pinion confined in a box screwed against the back of the dial-plate, and containing a rack suited to the pinion already mentioned, having a hook attached to the lower end, and sustained above by an heliacal steel spring. When this machine is not in use, the hand rests in a vertical position against a pin in the face of the dial; but when any weight is placed upon the hook, the spring is depressed, and the rack, acting upon the pinion, turns the hand to a figure upon the dial corresponding with the amount of the article to be weighed. These machines, which are very portable, and manufactured with great care, are exceedingly useful for most ordinary purposes, where particular accuracy is not required. With a suitable chair attached, it is very convenient for ascertaining the weight of the body, and is often used at the race-course, where jockeys are weighed.

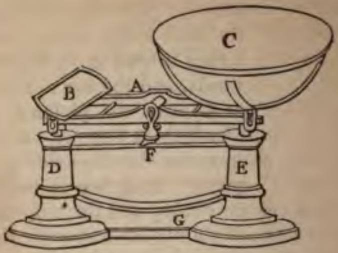
This method of indicating weight on a dial is probably of French origin. There is a machine of this description in the collection of the Society for the Encouragement of Arts, Manufactures, and Commerce, at the Adelphi, and which was figured and described in the Society's Transactions for 1791, vol. ix. This machine was presented by M. Hanin of Paris, and was so constructed, that the weights of the principal countries in Europe, and the relative proportions that they bear to each other, are shown at one view. *Fig.* 99. represents the back of M. Hanin's machine. It is suspended by the ring *a*. A weight being attached to the hook *b*, the spring *c*, made fast by strong screws at *d*, is drawn downwards, and the bar *e*, having a rack at *f*, turns the pinion *g*, to the axis of which is fastened an index which traverses the other side or face of the plate. That face is marked with a number of concentric circles, and the weights of twelve principal countries of Europe are engraved on it. When any weight is hung upon the hook *b*, the index traverses the dial till it rests upon those figures in the circles which show the weight at the different places named. The dial-plate is a permanent table, showing what weight of any of those countries is equal to so many pounds Troy of London, which are engraved on the outer circle, or to the pounds avoirdupois, which are marked on the second circle; and so of the rest.

Fig. 99.



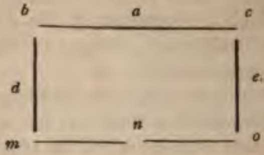
A very useful, compact, and ingenious contrivance, called a counter-weighing machine, has come into general use. In this machine it will be observed that the receptacles for the weights and the article to be weighed are placed above the beam, instead of being suspended underneath, as in the ordinary balance. The beam A (*fig.* 100.) is composed of two parallel bars, with three cross pieces terminating in suspension pivots — one in the middle, and one at each end. A table B is placed at one end, to receive the weights, and a dish C at the other, to hold whatever matter is to be weighed: this dish rests loosely upon a spandril or bracket, so that it may be conveniently taken off, and its contents instantly poured out by the shopman. Two hollow standards, D E, with the connecting piece F, and the channelled bottom G, consist of one stout casting of pig metal. The vertical motion of the table B and the basin C is obtained by a contrivance not unlike that which regulates the descent of the piston in the modern

Fig. 100.



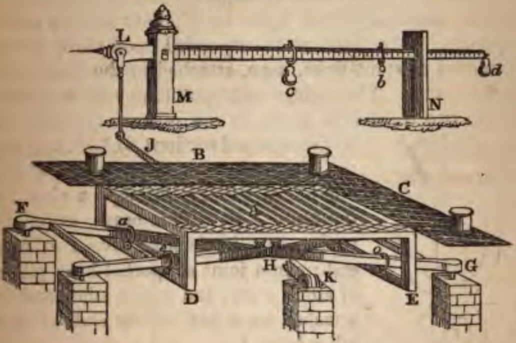
steam engine, and will be clearly understood from the annexed diagram.

Fig. 101.



In the above sketch, *a* is the beam, and *b c* the frames hanging on the pivots at each end; from these frames the tail pieces *d e* pass down the standards D E, (*fig.* 100.) and are jointed or linked to two iron rods at *m* and *o*, which again are linked to a centre at *n*. This ingenious contrivance effects the parallel motion of the dish or plate; but the number of points of contact, the friction of which has to be overcome, is increased at least from three to six in this, as compared with the common balance, and considerably more in actual amount, when we consider that the fastenings of the invisible rods at *m n o*, by no means resemble in delicacy of bearing the acute edge pivots at *a b c*, attached to the beam. It could only, however, be in very nice weighing that even the amount of friction here alluded to ought to form any objection to this exceedingly convenient and desirable machine. For all the ordinary purposes of shopkeepers, especially as connected with the weighing of gross articles from 7 lbs. to 112 lbs., this counter-weighing machine cannot be too highly estimated.

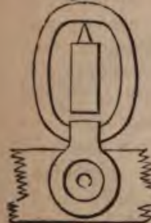
Fig. 102.



The instrument represented in *fig.* 102., is a machine by which weights of great amount, such as loaded waggons, are ascertained by means of a system of connected levers. Machines of this description, though formerly composed for the most part of wood, are now generally made of cast and wrought iron, including the floor upon which rest the wheels of the carriage, which with its load is to be weighed.

As far as they can be conveniently exhibited at one view, the different parts of a modern iron weighing machine, for loaded waggons, &c. are here represented. The cast-iron plate or platform A is twelve feet long by seven feet wide: on this the vehicle to be weighed rests. It lies level with the ground, and is enclosed by an iron margin twelve inches wide, two sides of which are shown at B C. The iron knobs at the corners bind these plates together, and serve as guides for the wheels of a carriage upon the plate. Under the edges of the platform are strong metal beams for giving strength; and at each end the massy cast-iron frames D E, are fastened with screws and also with wrought-iron bridles, omitted in the delineation to render more conspicuous the material parts. Two triangular levers, which are marked F and G, pass through the frames above mentioned; their ends rest upon iron points in the stone supports. The platform is suspended upon these levers by means of stout links, *a e o*, attached to the lower bar of the frame. These rings rest upon four points, placed on the two transverse levers in the manner represented by the enlarged section (*fig.* 103.). Near the points where the levers meet, at H, are hooks passing through a ring in the beam J K. This beam, which is twelve feet in length, works at one end upon a joint supported by a pillar of stone work, and at the other end is attached by a bar to the end of another lever L.

Fig. 103.



The lever L, which in shape and action is similar to the common steelyard beam, is ten feet long, nine feet from the smaller end to the axis of suspension in the pillar M, and one foot from the latter point to the eye of the descending rod. Three weights are used for the following purposes: — *b* is a small one designed to restore the equilibrium of the machine, when deranged by wet or other causes; *c* is the common metal bulb, which is moved along the graduated line of the lever, to ascertain the weight of whatever may be upon the platform. The scale traversed by this bulb, from the axis to the guide N, will indicate 28 lbs. to 8 tons. When the load on the platform exceeds the latter weight, the ball *d* is hung upon the extremity of the beam, and the bulb *o* moved back again, by which operation the scale will now indicate about 4 cwt. more than before. It may be mentioned, that besides the construction of these ponderous machines, in connection with weigh-houses by the sides of the road, for the purpose of ascertaining whether or not vehicles of the given breadth of wheel carry loads in accordance with the act of parliament, and in markets, &c. they are often made on a smaller scale, and fixed level with the floor in warehouses and other places, for the conveniency of weighing casks of heavy goods, and large articles generally.

Different opinions have been entertained by writers who have treated on the subject, as to the weights used in this country anterior to the time of Edward III. The question has chiefly been, whether the avoirdupois pound of sixteen, or the Troy pound of twelve ounces, is to be considered as the more ancient. In favour of the former opinion, bishop Cumberland asserts, that "our old English avoirdupois ounce is the same as the Roman ounce, and was probably introduced into this country by the Romans, when they gave laws and planted colonies here, and has thence continued unchanged to this day; which is not commonly observed, because we use the avoirdupois weight only about heavier commodities — not in weighing gold or silver, which are weighed by the troy ounce, which I suppose was introduced by the Normans, because it takes the name from a French town, Troyes, in Champagne."

William the Conqueror, by his charter, confirmed to the English all their ancient laws, with such additions or alterations as appealed advantageous. The fifty-seventh clause of this charter, under the title of "De Mensuris et Ponderibus," ordained that sealed standards both of weights and measures should be made such as his predecessor king Edward had ordained. Unfortunately, neither the weights nor measures are more particularly defined. It is stated, however, in the Chronicon Pretiosum, that the Conqueror determined that a penny-weight should be equal to thirty-two grains of dry wheat; and subsequent statutes, especially that of 31 Edward I., explain the ancient weights. With reference to a similar radical, that is to say, the English penny, called a penny sterling, when coined without clipping, it was to weigh thirty-two grains of dry wheat taken from the midst of the ear, and twenty of those penny-weights were to make an ounce, and twelve ounces a pound. The Troy pound, derived from the above-mentioned standard, continued to be recognised as the legal weight in general use until the reign of Henry VIII., when this monarch, in the eighteenth year of his reign, abolished the old pound, and established the Troy. He declared that the latter was heavier than the former by three quarters of an ounce, the heavier weight having, in all probability, been sanctioned by his predecessor.

The Philosophical Transactions contain three or four articles on the subject of old English weights. One of the writers (Henry Norris, esq.) says, "What the weight of that pound was, which was raised from a penny-weight, equal to the weight of thirty-two grains of wheat, we may clearly learn from that declaration in the 18th Henry VIII., when he abolished that old pound and established the Troy weight, which says that the Troy pound exceedeth the old Tower pound by three quarters of an ounce. As the Troy pound established by Henry VIII. is the same as is now in use, consisting of 5760 Troy grains, and 480 grains to the ounce, and twelve ounces to the pound; so 360 grains are three quarters of the ounce, which, deducted from 5760, leaves 5400 Troy grains, equal to the weight of that old Saxon pound which he abolished. But to trace out experimentally the weight of that penny-weight, raised from thirty-two grains of wheat, I got a small sample of dry wheat of last year (1773) (the weight of the ear but ordinary), and from a little handful of it I told out just ninety-six round plump grains, dividing them into parcels of thirty-two grains each, and all three weighed exactly twenty-four and a half Troy grains; consequently 240 such penny-weights, which the old pound consisted of, were equal only to 5400 of our present Troy grains, conformably to the declaration of Henry VIII. Thus the weight of that old pound is clearly ascertained to have been lighter than the present Troy pound by three quarters of an ounce, and this clearly shows that they were two different weights."

The origin of the present avoirdupois pound of sixteen ounces, equal to 7680 Troy grains, is involved in obscurity, notwithstanding the hypothesis of bishop Cumberland. The earliest occurrence of the term itself in our laws, is in a statute of 27th Edward III., where it is recited, that "some merchants bought avoirdupois merchandises by one weight, and sold them by another." Until the middle of the sixteenth century, the retail butchers sold their meat in the market by hand; but Henry VIII., in the 24th year of his reign, obliged them to provide themselves with beams, scales, and avoirdupois weights, sealed. Although this "haberdupoise" weighing was not then for the first time insisted on, it does not appear that the royal authority interfered with the weights themselves, which most likely were similar to those which had long been in use for the weighing of gross commodities, though until that period never legally sanctioned. In the next reign, both the Troy weight and the avoirdupois weight, now remaining as standards in the exchequer, were deposited there.

The former of these sets of standard weights consists of a pile or box of hollow brass Troy weights, from 256 ounces downwards to the sixteenth part of one ounce, all severally marked with a crowned E.; these are not accompanied by either penny-weights or grains that are considered as standards. The standard avoirdupois weights kept in the exchequer are these: a fourteen pound bell weight of brass, marked with a crowned E., and inscribed

XIIII POUNDE AVERDEPOIZ
ELISABETH REGINA
1582.

Also a seven pound, a four pound, and a single pound avoirdupois bell weights; and severally marked as follows, excepting the variations for the number of pounds in each weight respectively:—

VII. A

AN°. D°.

E L

1588

A° REG XXX.

With the foregoing are also kept a pile of flat avoirdupois weights, from fourteen pounds down to the sixty-fourth part of a pound. The founders' company of London are, by their charter from king James, authorised and directed to have the sizing and marking of all manner of brass weights, to be made or wrought, or to be uttered or kept for sale, within the city of London, or three miles therefrom. And the weights delivered to them from his majesty's exchequer, and now kept in their hall as their standards for the uses above mentioned, are a pile of flat brass Troy weights, from 256 ounces down to the sixteenth part of an ounce, all sealed with the exchequer seal, and marked with C R, crowned, 1684, and a stamp of the initial letters of the maker's name; also a set of brass avoirdupois weights, sealed and marked in like manner.

By an act of parliament passed in June, 1824, for ascertaining and establishing uniformity of weights and measures, it was enacted, that from and after the first of May, in the following year, the standard brass weight made in 1758, and then in the custody of the clerk of the house of commons, should be considered the original and genuine "measure weight," and moreover should be, by the same act, denominated the imperial standard pound Troy, and the unit from which all other weights should alone be derived, computed, and ascertained. The act, after declaring that the 5760th part of the said Troy pound shall be taken for one grain, declares that 7000 such grains shall be a pound avoirdupois; that one sixteenth of such pound shall be an ounce avoirdupois, and one sixteenth part of such ounce a dram.

The plan laid down in this act of parliament for correcting or restoring the standard of weight, should it ever be injured or lost, will be sufficiently interesting to the general reader to justify its quotation in the words of the original statute ;—" And whereas it is expedient that the said standard pound Troy, if lost, destroyed, defaced, or otherwise injured, should be restored of the same weight, by reference to some invariable natural standard: and whereas it has been ascertained, by the commissioners appointed by his majesty to inquire into the subjects of weights and measures, that a cubic inch of distilled water, weighed in air by brass weights, at the temperature of sixty-two degrees of Fahrenheit's thermometer, the barometer being at thirty inches, is equal to 252 grains, 458,000th parts of a grain, of which, as aforesaid, the imperial standard Troy pound contains 5760; be it therefore enacted, that if at any time hereafter, the said imperial standard Troy pound shall be lost, or shall be in any manner destroyed, defaced, or otherwise injured, it shall and may be restored by making, under the direction of the lord high treasurer, or the commissioners of his majesty's treasury of the United Kingdom of Great Britain and Ireland, or any three of them, for the time being, a new standard Troy pound bearing the same proportion to the weight of a cubic inch of distilled water, as the said standard pound hereby established bears to such cubic inch of water."

Several parliamentary commissions have been appointed to consider the propriety of some new adjustment of the English weights and measures, with a view to the adoption of a more uniform system than that at present in use. An adjustment of the standard of measure (the Imperial) has been effected, but the divisions of weight remain unchanged. Ou does not admit of any description of the b employed at the Bank of England and at the Mi weighing and separating the heavy and light sove —instruments which are remarkable examples genuity.

CHAP. XIV.

MISCELLANEOUS ARTICLES.

SADDLER'S IRONMONGERY. — ANTIQUITY OF STIRRUPS. — SPURS. — BRIDLE-BITS AND BRANCHES. — MANUFACTURE OF THIS DESCRIPTION OF ARTICLES. — CASE-HARDENING. — PLATING ON STEEL. — BAGNAL'S PATENT RINGS. — LANCASHIRE TOOLS. — PERFECTION OF THE WARRINGTON MANUFACTURES. — BIRMINGHAM STEEL TOYS. — INVENTORY OF SMALL WARES FORMERLY IMPORTED INTO THIS COUNTRY. — SHOE-BUCKLES. — CAPRICE IN FASHION OF SHOE-BUCKLES. — POLISHED STEEL TRINKETS. — STEEL PENS. — PERRY'S, HEELEY'S, SKINNER'S, MORDAN'S, AND GILLOT'S PENS.

Before we dismiss the subject of manufactures in iron and steel, it may be proper to mention a few of those miscellaneous wares fabricated out of one or both of these metals, and which do not fall properly into any general classes. These articles are, in fact, infinitely diversified in form and purpose: they afford occupation to an immense number of hands in the workshops, and yield, of course, a proportionately large amount of trade influence and income to those who direct the complex and expensive arrangements for their production on a large scale. The matters about to be mentioned have no connection with each other, further than that they are mostly found exposed together for sale, in the shop of the hardwareman or the ironmonger: neither is it intended to describe in detail the processes of fabrication, which would not often be intelligible without being verbose; and still seldomer would the interest, which a reader might take in the perusal of such details, be likely to reward his patience. Articles, however, with which almost every person must be more or less familiar, demand some notice. These are commercially known as Birmingham wares.

Bridle-bits, Spurs, Stirrups.

It might not unreasonably be supposed, that for the three articles of saddler's ironmongery named at the head of this paragraph we should claim an antiquity coeval with the art of equitation itself. This, however, is so far from being the fact, that no such early claim can be substantiated, even for the invention of the saddle. In the earliest ages, it appears certain that the rider sat upon the back of the horse without a solid seat; and long after some sort of covering became common, it did not at all resemble our saddles, but was used as much for show as for convenience. The old Germans are said to have considered the use of saddles disgraceful, and to have despised the Romans who used them, perhaps adopting them from the Persians. At what time they became common among the Greeks and Romans does not appear; it is certain, however, that when they came into use, they were not only considered indispensable, but made of the most costly materials, and in the most sumptuous manner; so much so, that the emperor Leo I. issued an edict prohibiting them from being adorned with pearls and precious stones. The earliest authentic mention of saddles is supposed to be in an order of the emperor Theodosius, in the year 365, by which those who wished to ride post horses were forbidden to use saddles weighing more than sixty pounds.

An old saddle with stirrups was two centuries ago shown to travellers at Rome, as having belonged to Julius Cæsar. The credulity that might have, perhaps, been pardoned for looking with veneration upon the ancient saddle, ought certainly to have been shocked with the anachronism of its appendages; for stirrups are of undoubtedly more recent introduction. In neither Greek nor Roman authors, even those who have described the furniture of horses, does there occur any mention of stirrups, — the Latin word *stapes*, supposed to be formed from the German *staff*, a step having been first used in the fourteenth century.

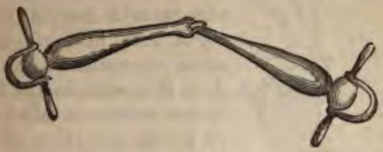
Although the ancient equestrians were expected to be able to vault upon their saddles with as much agility as persons accustomed to ride now gain them by means of the stirrup, mounting stones were common on the continent of Europe. They are occasionally seen to this day in some places, though only generally used by females. Various other methods of mounting were devised, and amongst the rest that of stepping upon the back of a servant. On which account, conquerors sometimes subjected their vanquished enemies to this degrading humiliation. In this ignominious manner was the emperor Valerian treated by Sapor, king of Persia. According to Beckmann, stirrups are clearly mentioned before the end of the sixth century, in a book by Mauritius on the art of war, in which the author says, that a horseman must have at his saddle two iron *scalæ*. In the case of stirrups, as of other luxuries growing out of refinement of manners, it seems those who first adopted them were derided by others, who either dispensed with or could not procure them. They were charged with effeminacy and innovation. In the twelfth century they became comparatively common.

Spurs, although the period of their introduction is unknown, are of inferior antiquity to stirrups, as well in this country as elsewhere. Both stirrups and spurs, however, were known to the Anglo-Saxons, as appears from contemporary sketches, though they are sometimes represented riding without either. The Saxons probably introduced spurs into England, but, from the earliest delineations extant, it appears that the rowel was not in use. Its purpose was answered by a single point, as may be seen from several of the plates in Strutt. The rowel occurs for the first time in a sketch belonging to the latter end of the thirteenth century. At this time, and long afterwards, the spurs of cavaliers were heavy and cumbersome, as may be seen from the antique specimens preserved in the cabinets of the curious.

The use of iron bits to which the bridle is attached appears to be as old as the art of horsemanship itself. Xenophon, more than 400 years before Christ, mentions them as being in use in the Grecian states; and the apostle St. James has a striking expression illustrative of their use, and from which it seems they were generally known in his time. The bit, in its simplest form, was probably nothing more than a small bar of iron, with a loop at each end, passed between the jaws and over the tongue of a horse, to enable the rider to command the guidance of his beast by pulling the reins to the right or to the left. The earliest alteration would be to give the bit a degree of curvature in the middle, so as to relieve the horse's tongue, and by this means a considerable amount of suffering would be taken away. As this alteration would, however, in a corresponding degree, diminish the rider's command of the horse's head, other contrivances would be resorted to make up the deficiency with restive animals; and this seems to have led to the common snaffle, and afterwards to the far more efficient and now general curb bit, having a chain passing under the chin, and a cross piece of metal fastened at each end of the bit outside the mouth, and serving as a lever, by means of which the bridle may operate so as to pinch the lower chap very tightly.

Hence, although by bits, strictly speaking, be merely meant one or two links of iron placed within a horse's mouth, and to the outer end of which the bridle for the direction of the animal is attached, the term is now understood in a more comprehensive sense, as including, in all its variety and extent, the metallic apparatus usually placed within and without side the mouth of a horse, and upon which the reins are made to act with a mehanical effect. In this larger acceptation, therefore, includes the bits or mouth pieces properly so called,

Fig. 104.



e curb which passes underneath the chin, and the anches which lie parallel with the cheeks of the horse. he most common and simple form of linked mouth on as already stated, is the snaffle, which, however versified in make and strength, is derived from the d musrol or watering bit. The form of this bit, it will observed, affords the utmost liberty to the tongue: iere have been a variety of others, by no means so entle in their fashion for the management of hard iouthed or stubborn horses; the most common of these , what is called the port mouth, and is used with the urb chain bridle: this bit consists of an entire bar iveted to the branches, and having a curb in the mid- lle nearly in the form of a Greek Ω. When the bridle s down very tight, this rise in the bit is made to press ard against the roof of the horse's mouth, at the same ime that the curb chain closely presses the chin. Old riters on these matters mention bits with mouth knobs sembling melons, balls, pears, &c. These clumsy ntrivances, except in the breaking bit of young horses, ave long since yielded to the more scientific and ef- cient adaptation of the various kinds of branches.

The French paid much earlier attention to equestrian ercises than the English, and we derived from that ople most of our old fashions of horse furniture: e branches first seen in this country were brought om France; they were, however, soon imitated, d ultimately surpassed by our own artists. The form of the branch anciently, as at present, was diversified in every degree, from a straight line or pistol shape to the utmost knee bent. *Fig.* 105. represents a branch much in vogue with first-rate horsemen about two centuries ago. From A to B is what in the language of the *ménage* is called the line of the banquet, C to D arch of the banquet, E the banquet, F the eye into which the curb chain is linked, G the sevil hole, to which the bridle is attached.

Fig. 105.

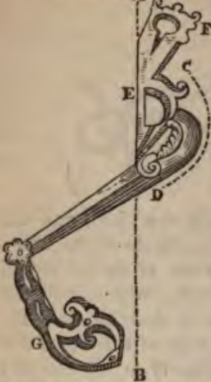
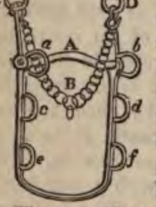


Fig. 106. represents the most fashionable and efficient gig-bit, at present in use. A is the curb chain, B the port mouth, C D the cheeks or branches, composed of one unbroken rod of iron, the lower part of which hangs down under the mouth of the horse: *a b c d e f* are iron loops raised in the substance of the cheeks, and to which the curb chain is attached higher up or lower down as the animal may happen to be hard mouthed or otherwise, and thus render a greater or a less degree of leverage necessary to manage him.

Fig. 106.



The manufacture of all the metallic parts of horse furniture was carried on at an early period in London, by artisans, incorporated under the denomination of loriners and spurriers. In more modern times, however, saddlers' ironmongery of every sort has formed a large part of the staple trades of Birmingham, Walsal, Wolverhampton, Wednesbury, and places adjacent; where, for cheapness in the common, and perfection in the best articles, the workmen are at present unrivalled.

Curb chains and branches, as well as the various metallic articles belonging to coach and other harness, are made of iron or steel, japanned, tinned, burnished, or plated with brass or silver, and in some cases still more expensively ornamented at the option of the makers and purchasers. The ordinary bright articles of this class ought to be forged out of good iron, and afterwards case-hardened. When the material has been first rudely fashioned on the anvil by the hammer, it is then brought into its final shape by filing. Vast quantities are cast in sand moulds, with that kind of run steel which is so largely used in the production of common table-knives and forks. As articles cast from the best sorts of native iron admit of being annealed so as to unite a considerable degree of elasticity and tenacity of body with a good polish, many pieces of the metal work used by the harness maker may without danger be so manufactured. But as in dealing with a spirited horse, either in harness or when mounted, the lives of individuals so frequently become dependent on the stability of the metallic parts of the reins or other trappings, it is certainly a matter of serious consideration, not only to know that good materials but good workmanship characterise such articles.

The usual method of case-hardening is to place the iron articles in a close coffer, or other vessel, filled with animal carbon, such as burnt leather, bones, hair, &c. and then submit the whole to a regular heat, for some time. Pure iron may likewise be superficially converted into steel, so as to harden, temper, and receive a fine polish, by being surrounded with the turnings from cast iron, and in this state submitted to the action of the fire. There are various other processes which may be resorted to for this purpose, more or less simple in their nature. The following composition, to be used instead of charcoal in the process of converting iron into steel, was specified at the patent office, in 1825; and, from the number of ingredients, reminds us of the empirical prescriptions of the 15th century. This mixture is as follows:—" Take one ounce of sal ammonia, one ounce of borax, one ounce of alum, one quart of fine salt; put them into an iron or other metal vessel, stir them well together, and heat them till the vessel is red hot, and the same ceases to smoke; then, after it is cool, pulverise it to a dust; afterwards, take four quarts of strong soot, two quarts of pulverised burnt leather, two gills of burnt horse hoof, one pint of fine salt, one quart of vinegar, and two quarts of urine; put them into an iron or other metal vessel, stir them well together to the consistence of mortar, then boil it down, stirring it well till it becomes perfectly dry like dust: then after cooling it, take the first-mentioned composition, and sift it through a fine sieve, mixing it at the same time with the second composition: the mixture is then to be sifted upon the iron to be converted, *stratum super stratum.* My experience," says the patentee, "has found the above proportions to form a suitable quantity for converting about one hundred weight of iron (articles) of ordinary sizes."

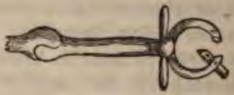
In the present day, not only spurs, bridle bits, and horse furniture in general, as before stated, but likewise a great number of other articles, are plated with silver upon steel, thus adding to the strength of the solid material the beauty of the precious metal with which it is covered. In the best workmanship, the article, after being filed clean and smooth, is wrapped all over with a fillet of sheet silver, which is fastened with small wire: after which, borax ground with water is laid upon the surface and sprinkled with silver solder; it is then heated red hot, so as to braze the silver to the iron. The surface is then filed smooth, burnished, and otherwise got up as silver. More commonly, however, the metallic parts of harness, and a vast variety of other wares, are covered with silver by soft soldering. The process of plating articles of this description is as follows:—The piece is, in the first place, filed all over the surface, so as to be perfectly clean and bright; it is then tinned in the usual manner, by dipping in a vessel of melted tin, and wiped over with hurds, so that no more than a very slight coating may remain. A foil of silver, beaten very thin, is then cut of the size of the article, and folded upon it as perfectly and closely as possible. In the flat parts it is beaten close with a small hammer, covered with cloth; while, upon the mouldings and in hollows, the foil is rubbed down with a sort of wooden burnisher. When the silver film has been properly closed upon the steel, in every part, so as to adhere, as it will do from contact, a heated doctor, or soldering bit, very similar to that used by the tin-plate workers, is passed over every part of the surface, by which operation the tin and silver are united, and the pellicle of precious metal adheres to the body of the article with considerable tenacity.

To make the attachment still more perfect, the surface is now sprinkled over with powdered rosin, and heated over a charcoal or clear coke fire, gently urged by the bellows, the article being frequently withdrawn and dipped into the powdered rosin, in order to flux the tin. A piece of rod solder is next applied freely upon the surface; so that, by repeatedly re-heating, the greatest certainty of its being secured is attained. When the latter object is believed to have been gained, the article is withdrawn from the heat and carefully wiped over with the hurds and oil, in order to remove as much as possible the tin and solder from the surface, which is still more completely effected by buffing the surface with fine sand.

When the shape of the article permits, it is then furbished all over with a dead smooth file, and afterwards rubbed with a Charley forest-stone of a peculiar grain. It is next got up by the application of a stick covered with soft leather and dressed with burnt rotten stone and oil, and, finally, finished, or "coloured," on a buff of buck-skin with fine dry sifted rotten-stone. The blades of fruit-knives are frequently plated by this method, being thus much cheaper, and certainly more useful, than when made entirely of silver; for to the appearance and cleanness of the precious metal are added the sharpness, the firmness, and the elasticity of the steel.

The leather part of bridles and other straps usually pass through metal rings, after which they are fastened with buckles. An ingenious attempt has been made to do away with this arrangement by a contrivance rather novel in its application than in its principle. In 1811, a person of the name of Bagnal, of Walsal, saddler's ironmonger, obtained a patent for a method of making bridle-bits, snaffles, and bradoons for horses, martingale hooks, and rings of iron and steel, which consisted in making the rings (*fig.*107.) with an opening or division, which was closed by means of levers, slides, pins, catches, or other contrivances; so that the leather, instead of requiring to be looped by buckles or fillets, had a permanent loop of the whole strength of its substance; which loop might be taken off the ring through the opening at pleasure, either for the purpose of cleaning the metal or using the bridle at its length to lead the horse, as is sometimes desirable, without the trouble of unbuckling. The patentee remarked, that his contrivance might be particularly useful in military cases, when it was often necessary to fasten a number of horses suddenly to one spot; while the riders, as sometimes happens with cavalry, quitted their horses for a time.

Fig. 107.



Lancashire Tools.

Under this comprehensive designation is comprised an immense variety of articles, chiefly used in the manipulatory processes, by almost every class of artificers in this country, and, indeed, by many persons beyond it. The acknowledged superiority of the Lancashire files has been already mentioned, as well as the fact, that such superiority belongs less to the material than to the methods of workmanship. To files may be added chisels, graving, watch and clock makers' tools, hand vices, pincers, metal and wire gauges, cutting pliers, and an extensive variety of articles, of which the foregoing may be taken as specimens. The metropolis of this trade is Warrington, where, in the old established manufactory of Stubs, every one of the numerous articles sold under the name of "tools," in the common meaning of the term, is produced in a style of perfection not, probably, to be surpassed in the world. In this line even Birmingham yields the palm of superiority to Warrington. There is, for instance, one of the implements named above, which must always, on being examined by an artist belonging to any other hardware branch, excite his admiration — that is, the pliers commonly used for cutting wire. The appropriate symmetry of the shape, the exquisite fitting and working of the joint, the regularity of the filing of the whole, the accurate meeting of the edges, and the admirable tempering, render this little tool a curiosity in the estimation of those who can conceive how large a degree of accuracy of hand must have been requisite for its production. Many of these productions are made of iron, and case-hardened ; and these, as well as those wrought out of steel, are stripped with a smooth file, and then finished in a peculiar style of blackness, except just at the cutting part, which is ground and polished.

Heavy Steel Toys.

By this not very appropriate description the Birmingham manufacturers refer to a class of articles, differing but little, in most respects, from those last mentioned. Instead, however, of being formed with such admirable symmetry, and exhibiting such rare workmanship as the former, these rather appear like cheap imitations of the articles with which they may be directly compared. Instead, too, of being got up black, as is the case with the Lancashire articles, these Birmingham goods are filed bright, and slightly burnished. To enumerate all the "toys" of this class would be to transcribe a large list of miscellaneous cheap and useful wares, from a joiner's hammer to a shoemaker's tack. The pincers of the last-named workman, and the edged nippers commonly in use for breaking up loaf-sugar, are both of them well-known specimens of the extensive manufacture now adverted to; they exhibit, likewise, in the jointing—which, however, is perfect enough for the purpose intended—a striking contrast with that close fitting which is so much admired in such of the Lancashire tools as operate on a similar principle.

Light Steel Toys.

Birmingham has long been noted for the superiority of its workmen in the production of an endless variety of steel trinkets, for which this country was formerly indebted to Milan, Berlin, and other foreign marts. As in the manufacture of the greater part of the articles, properly ranking under the foregoing denomination, the worth of the material constitutes but a very small fraction of the ultimate value, the expenditure of ingenuity and workmanship constituting the remainder, it is the policy of the state no less than the interest of the artisan to encourage the home production of this description of wares. Whether with a laudable view to afford such encouragement to native genius and industry, or on other grounds, various enactments have, at different periods of our history, been resorted to for the regulation of the trade in those "small wares," the sale of which constituted, in no small degree, the staple of ancient pedlery.

As a curious inventory of metallic articles, the importation of which was interdicted at an important era of our mercantile history—the reign of the earlier Tudors—it may not be uninteresting to cite a clause from an act of parliament passed in the time of Henry VII. Among the articles which it was enacted that no "merchaunt straungers" should "brynge into the reolme of Ynglond to be soulde," we find mentioned, "mans gyrdylles, harynis wrought for gyrdylles, poynts, laces of lede, purses, pouches, pynnes, knyvys, hangers, taylour sherys, sesors, and yrens, cobords, tonges, fyer forkes, grydyrens, grydyren stocks, cocks, keys, hinges, ayny betyn gold, or betyn silver, horse harneys, bittes, storoppes, bokelles, chaynes, latyn nailes with yren shonkes, currets, stondynge condlestickes, hongying condlestickes, holy water scoppers, chafyinge dyshes, hongyng lavers, curten rynges, clospes for gloves, bokelles for shoys (shoes), spones of tynn and lede, cheynes of wyre, as well laten as of silvere, grates," &c.

The dreadful riot which occurred on what was afterwards remembered as "evil May day," in 1518, was in consequence of a rising of the Londoners against the great number of foreigners who then crowded the suburbs of the city, and made or sold a variety of wares, to the great prejudice of the native artificers. Speaking of the interlopers, Hall, in his life of Henry VIII., says, "There were such numbers of them employed as artificers, that the English could get no work." They not only resided in this country as competitors with our then merchants in the exportation of tin, lead, &c., but they starved the home workmen by importing from

Holland a variety of articles, chiefly small iron ware, such as nails and locks. Macpherson, in his Annals of Commerce, adverting to this riot and these strangers, says,—"The pretended crimes of these foreigners were, probably, their working cheaper, and being more industrious than our own people, whose exclusive privileges within the city kept the foreigners in the outparts, and out of the freedom."

Birmingham, which now produces, with so much reputation, almost every article above named, was all but unknown for any credit that attached to its hardware productions in the reign of Henry VII. One article, of very ancient use in this country, and the manufacture of which contributed largely to the employment of Warwickshire ingenuity, during the last century, the shoe-buckle, is now almost forgotten. Insignificant as it may seem at the present day, the time was when almost every shod foot in the kingdom was dependent on the buckle for its garniture: the celebrated works of the Soho, which have been so widely celebrated for the coinage of British and other money, and still more so for the improvement, almost the *invention*, of the steam-engine, originated with the manufacture of those small steel articles of which buckles constituted so important a part. Boulton and Watt must ever be mentioned together in connection with the Soho works; but it is hardly hyperbolical to say, that the patent steam-engines of the latter individual have not been more extensively known in this country of late years, than were, at one time, the patent shoe-latchets of the former.

A curious history might be written of the introduction and disuse of the shoe-buckle. Hutton of Birmingham, with his characteristic quaintness, thus notices it, in connection with the seat of its former manufacture:—"This fashion (of piked toes), like every other, gave way to time, and, in its stead, the rose began to bud upon the foot; which, under the house of Tudor, opened in great perfection. No shoe was fashionable without being fastened with a full blown rose. Ribands of every colour, except white, the emblem of the depressed house of York, were had in esteem; but the red, like the house of Lancaster, held the pre-eminence. Under the house of Stuart, the rose withered, which gave rise to the shoe-string. The beaus of that age ornamented their lower tier with double laces of silk, tagged with silver, and the extremities were beautified with a small fringe of the same metal. The inferior class wore laces of plain silk, linen, or even a thong of leather; which last is yet to be met with in the humble plains of rural life. But I am inclined to think the artists of Birmingham had no great hand in fitting out the beau of the last century.

"The revolution was remarkable for the introduction of William, of liberty, and the minute buckle, not differing much in size and shape from the horse-bean. This offspring of fancy, like the clouds, is ever changing—the fashion of to-day is thrown into the casting-pot to-morrow. The buckle seems to have undergone every figure, size, and shape of geometrical invention. It has passed through every form in the whole zodiac of Euclid. The large square buckle, plated with silver, was the *ton* of 1781. The ladies also adopted the reigning taste: it was difficult to discover their beautiful little feet, covered with an enormous shield of buckle; and we wondered to see the active motion under the massive load. Thus the British fair supported the manufactures of Birmingham, and killed by weight of metal." The change of fashion that ensued was disastrous to a large class of ingenious artisans, who were compelled to suffer, though not in silence, the loss of their usual employment. In 1791, a deputation of master buckle makers, from Birmingham, Walsal, and Wolverhampton, waited upon the prince of Wales, (afterwards George IV.) at Carlton House. The object of their audience was to present a petition, setting forth the distressed situation of thousands of individuals in the different branches of the buckle manufacture, in consequence of the fashion then prevalent of wearing strings. His royal highness received the petitioners very graciously, and, as a proof of his sympathy, not only resolved to wear buckles himself, but to order that his household should do the same. The royal example and the royal command were alike nugatory, when opposed to the dominion of fashion:—strings became general; and, in 1812, to adopt the words of Hutton, "the whole generation of fashions, in the buckle line, was extinct: a buckle was not to be found on a female foot, nor upon any foot except that of old age."

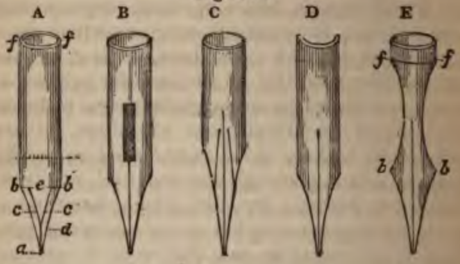
During the period referred to by the Birmingham historian, Bolsover in Derbyshire, now only noted for its castle, was famous for the manufacture of superior steel buckles. The test of their excellent temper, still traditionally reported in the neighbourhood, was, that though the wheel of a loaded cart should pass over a Bolsover buckle, the latter, in consequence of its elasticity, would not suffer any permanent alteration of shape. Metal clasps, formerly so common for fastening the shoes of children, seem, in their disappearance, to have followed the buckles of the men and women, as they are now rarely met with. What, however, does remain of the shoe buckle and clasp trade is mostly confined to Walsal, where, as before stated, buckles, rings, territs, and other things belonging to harness of all kinds, are manufactured.

It would be useless, not to say impossible, to enumerate all the articles of a useful or ornamental nature which are composed of polished steel, from the buckles already mentioned to the small beads still occasionally purchased by the fair sex. The following description of the method of polishing steel ornaments is given in the Technological Repository: the hardened steel is either polished flat, like glass, or cut into facets, like a diamond, consequently the lapidary's mill is used. The workmen commence by smoothing the work with rather coarse emery, then with finer emery, and finish with the finest. The smoothing being perfected, they polish it with English rouge, trit-oxide of iron, and oil, and finally finish it with putty of tin (peroxide of tin) and water. When the steel articles consist of raised and hollow work, they are smoothed and polished with the same substance; but the instruments are, as in the case of less harder metals, pieces of wood, properly shaped, and employed in the same manner: sometimes also the circular brush is used. We have, of late, witnessed something like a revival of the taste for polished-steel ornaments, in the purse snaps, girdle clasps, and similar productions of the Birmingham workshops. It were, indeed, to be wished, that a manufacture so peculiarly British, as well as profitable and beautiful, might never be suffered to decline; but, like other ornamental arts, steel toy working must be left to its chances of general depression and casual revival: fashion is, in most cases, too capricious in its influence to yield to any arguments in favour of native industry in its general scope, much less to those urged in behalf of any particular branch of it.

Steel Pens.

The use of metallic pens is by no means of modern date in this country: they have, however, when designed for any other purpose than *to sell,* been usually made of silver, though, during the last fifty years, tens of thousands of brass ones, some neat and some clumsy, have been manufactured and sold along with the varieties of cheap inkstands of the same metal. Lately, however, there has been an extensive trade carried on in steel pens: these articles, which differ considerably in their construction, are mostly prepared with considerable care and success; so much so, indeed, that the quill-venders have found their occupation to fall off in an extraordinary degree. This rage originated chiefly, if not altogether, in the successful speculations of Mr. James Perry of London, whose pens, however short their merits may fall of the praise of the inventor, are certainly superior to most others composed of a like material. These pens are made by metropolitan workmen, out of the best sheet steel, carefully manufactured in Sheffield for that express purpose.

Fig. 108.



Besides the quality and temper of the material, the distinguishing peculiarities of the Perryian pen, according to the inventor, "chiefly consist in its possessing, between the point *a* A (*fig.* 108.) and the shoulders *b b*, an internal forked slit, *c c*, which unites with a straight slit, *d*. By this simple means is produced in metal the same softness as in the quill pen, and with the same length of the springing parts. Here it will be perceived that the tongue *e*, formed by the internal forked slit *c c*, might be totally removed, so as to form in the pen a triangular aperture, and it is obvious that the softness obtained would remain the same. Further, it is obvious that, by making the aperture of an oval, a circular, a square, or other form, *so long as it is between the point* a *and the shoulders* b b, it would produce the softness required. Accordingly, all these varieties are noticed in the specification, which has been enrolled, of this patent." That the triangular incision in Mr. Perry's steel pen is a novelty, there can be no doubt: the punching of a round hole in whatever part, however, and then cutting the slit into it, is by no means new, as regards brass pens, at least. Of the pens made with a long slit, Mr. Perry remarks, with nearly as much correctness as confidence, that "as it is impossible that a metallic pen, which has an internal forked slit any where between its obtuse end *f f* and shoulders *b b*, should possess the same softness as one having it somewhere between the point *a* and the shoulders *b b*, so it is as utterly impossible that a metallic pen, which has an aperture any where between its obtuse end and shoulders, should possess the same softness as one having an aperture somewhere between the point and the shoulders."

Fig. B represents a pen with the aperture between the obtuse end on the shoulders.

Fig. C is "Heeley's rhadiographic pen," which has had a considerable run; especially as it has been sold much cheaper than the Perryian.

Fig. D is a pen, or rather a steel nib, manufactured by John Skinner of Sheffield: it is made of a stouter material than any of the others; is very firm in its action, gives down the ink freely, neither "spirtles nor scratches" the paper more than the kindliest metal may be expected to do; in short, for common, rough writing, it is a cheap, useful pen.

Fig. E is a regular, long-slit pen; having the barrel, moreover, filed away, between the shoulders *b b* and the obtuse end *f f*, in order to aid the flexibility of the nibs. This is probably one of the least efficient of the many forms which the metal pen has assumed.

Mr. Mordan has recently introduced a steel pen, the bit of which, instead of resembling any of the foregoing, is dished somewhat in the form of a bird's head, the slit in it being oblique to the handle or holder.

Steel Pen making has within the last few years developed itself to an extent which would appear incredible, unless to those acquainted with the subject. The history of a Steel Pen is among the wonders of the present day: it is to us what pin making was to our ancestors,—a thing to be wondered at: we have the ore smelted and converted into iron, and the same changed into steel, then it is rolled into ordinary sheets, in which state it is received from Sheffield, when it is cut up into strips, pickled to remove the scale, and reduced also by rolls to the requisite thickness: in this condition it is passed into the hands of a female, who is seated at a small press, worked by hand, and who cuts out, with a single blow, a thin flat piece of steel, which is the future pen; side slitting and piercing then follows, which is also performed by hand press, fitted up with punch and bolster; there, after the blanks in this condition are annealed in considerable quantities in a muffle, stamping with the maker's name then follows, pressing into the concave form is the next process, and the operation of forming the barrel (if a barrel pen) is now completed. Hardening, an operation which requires no little care and attention, is also performed by heating in a muffle, and when at a proper heat they are immersed in oil; the oil is then cleansed off them by agitating in a cylinder, and scouring follows by the same method, with the exception, that pounded crucibles and other cutting substances are introduced along with them, which in the end produces on one and all a bright surface; the grinding on the point, &c., is performed on an emery wheel, and is effected with great rapidity; in this state the pens are passed to the "slitter," who is provided with a pair of cutting tools, which are fitted into a hand press; their accuracy in fitting is such that a careful examination is necessary to detect that they are not one; the pen is rested upon the portion attached to the bottom of the press, the handle turned, and the slit is made; the shades of blue and straw colour with which the pens are ornamented, are also produced by heat, the pens are introduced in large quantities into a cylinder which is made to revolve on a charcoal stove, and the change of colour is watched, when that which is desired is obtained, the cylinder and its contents are removed, the brilliant appearance of the external surface is given by lac dissolved in naphtha, heat is thereafter applied, when the spirit is evaporated and the lac alone remains, lending to the pens that brilliancy of finish which adds so much to their appearance.

Those who desire a more familiar acquaintance with this now almost indispensable requisite for the expression of thought, and the facilitation of business, and to whom, in addition to the seeing the making of a Steel Pen, the examination of a well-regulated manufactory would afford pleasure, should by all means try to get a look at Mr. Gillot's manufactory, situated in Graham Street, Newhall Hill; where upwards of 500 hands are daily busily engaged in the production of steel pens, and where order and cleanliness, whether in the personal attire of the work-people, or in their work shops, is a distinguishing characteristic: of the number stated, 400 are females, employed in the actual production and papering up of the pens. The remainder are tool makers and workmen who are engaged in the more skilful or laborious departments, where female strength is not available. Considerable additions are at present being made to this establishment. Some idea of the extent to which this manufacture is carried, may be gathered from the fact, that there is annually 180 millions of pens produced at these works.

CHAP. XV.

WIRE-DRAWING.

WIRE FIRST MANUFACTURED BY HAMMERING AND FILING. — WIRE-DRAWING. — INTRODUCTION OF THE ART INTO ENGLAND. — PARLIAMENTARY PROTECTION. — BERLIN AND BARNSLEY WIRE. — RIPPING OR RUMPLING IRON FOR WIRE. — ROLLING. — ITALIAN DRAWING PLATES. — DESCRIPTION OF THE PROCESS OF DRAWING WIRE BY HAND AND BY MACHINERY. — DRAWING PLATES MADE OF GEMS. — FRENCH DRAWING PLATES. — WIRE MANUFACTURE IN FRANCE. — MM. MOUCHEL'S OPERATIONS IN WIRE-DRAWING. — STUB'S WIRE GAUGES. — DESCRIPTION OF A PROPOSED NEW WIRE GAUGE.

Besides the elongation of iron or steel into rods of whatever length, by means of hammering or rolling, as already described, the same materials, and most other ductile metals, may be drawn out into pieces exhibiting a capillary fineness, by means of an operation, the principle of which differs as much from that of the forge or the rolling-mill as those machines differ from each other. The manufacture of iron and steel wire gives employment, directly and indirectly, to a vast number of people, of both sexes, in this country: as a source of trade, therefore, no less than as a field of industry, it commands proportionate attention. Some idea may perhaps be formed of the extent to which the home consumption of iron and steel in the article of wire alone is carried, by a moment's recollection of the variety of uses to which it is applied: it may be sufficient here to mention the strings of musical instruments, woven and reticulated fabrics, carding and other machinery, and, lastly, needles. In the construction of bird-cages, no small quantity of iron-wire was at one time consumed; and even now, though the fancy for singing birds is perhaps abated, the consumption is considerable. In Paris, before the Revolution, the bird-catchers were a numerous corporation, the freemen of which had the sole right of making bird-cages, and were thus large consumers of wire.

Although the making of wire for a variety of purposes must be an art nearly as old as a knowledge of the working of metals, the method of drawing it, as at present practised, is by no means of such undoubted antiquity. Beckmann justly regards it as highly probable, that, in early periods, metals were beat with a hammer into thin plates or leaves, which were afterwards divided into small slips by means of a pair of shears, or some other instrument; and that these slips were by a hammer and file then rounded, so as to form threads or wire. This conjecture seems to be confirmed by the oldest information respecting work of this kind. When the sacerdotal dress of Aaron was prepared, the gold was beaten and cut into threads, so that it could be interwoven in cloth. We are told, also, that Vulcan, desirous to expose Mars and Venus, while engaged in their illicit amour, repaired to his forge, and formed on his anvil, with hammers and files, a net so fine that it could be perceived by no one, not even by the gods themselves; for it was as delicate as a spider's web. It is difficult to say at which of the features of this fabulous exploit our modern wire-drawers will most marvel — the production of a fabric so extraordinarily fine, and by such means, or the idea of immeshing the powerful god of war in so frail a trap!

Although the story just alluded to does undoubtedly imply the production of filamentous iron, it is indisputable that the earliest modes of manufacturing wire by any process, and especially by the drawing-bench, were first applied to the more ductile metals, as gold and silver; and more particularly the former, for the purposes of embroidery, or of its being interwoven with other materials into those curious and costly stuffs of which we have so many ancient accounts. The period, however, when attempts were first made to draw into threads ductile metal cut or beat into small slips, by forcing them through holes in a steel plate placed perpendicularly or otherwise on a table, is by no means determined. In the time of Charlemagne this process was not known in Italy; for, however unintelligible may be the directions given in Muratori *de fila aurea facere de petalis auri et argenti*, we learn from them that these articles were formed only by the hammer. "As long," says Beckmann, "as the work was performed by the hammer, the artists at Nuremberg were called *wiresmiths;* but after the invention of the drawing-iron, they were called *wire-drawers*, and *wire-millers*. Both these appellations occur in the history of Augsburg, so early as the year 1351, and in that of Nuremberg in 1360; so that, according to the best information I have been able to obtain, I must class the invention of the drawing-iron, or proper wire-drawing, among those of the fourteenth century." Iron-wire in France is called *fil d'archal;* and the local artists have an idea, not perhaps improbable, that this appellation took its rise from one Richard Archal, who either invented or first established the art of drawing iron-wire in that country. The expression *fil de Richard* is, therefore, likewise used among the French wire-drawers. As, however, nothing is actually known of such a person as Richard Archal, Menage is of opinion that *fil d'archal* is compounded of the Latin words *filum* and *aurichalcum*.

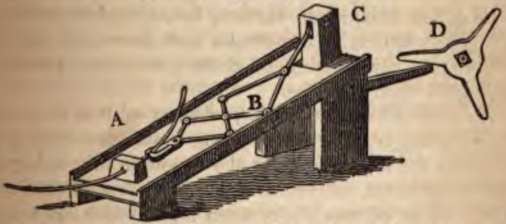
Of the introduction of the manufacture of wire into this country, we have no specific information. It has, however, been asserted, that all the wire in England was manufactured throughout by the hand till 1565, when the art of drawing it with mills was introduced by foreigners. Of these, Christopher Schultz, a native of Annaberg in Saxony, has been particularly mentioned. This person, who is reported to have come to this country under the permission given by queen Elizabeth to strangers, to dig for metallic ores, is said to have introduced the method of drawing iron-wire with engines, in the year above stated. Previous to that date, the hand-wire drawers performed their operations in the forest of Dean. Our countryman, John Houghton, in a book published at London in 1727, intimated that the art was brought hither at a still later period, and that the first wire-making was established at Esher by Jacob Momma and Daniel Demetrius, both foreigners. Before the period above mentioned, the English iron-wire had so little reputation, that the greater part of what was used in the kingdom, as well as the instruments employed by the wool-combers, was brought from other countries: improvement, however, rapidly took place, and the legislature encouraged the home trade. In a proclamation of Charles I., in 1630, it is set forth "that iron-wire is a manufacture long practised in the realm, whereby many thousands of our subjects have long been employed; and that English wire is made of the toughest and best Osmond iron, a native commodity of this kingdom, and is much better than what comes from foreign parts, especially for making wool cards, without which no good cloth can be made. And whereas complaints have been made by the wire-drawers of this kingdom, that by reason of the great quantities of foreign iron-wire lately imported, our said subjects cannot be set on work; therefore we prohibit the importation of foreign iron-wire, and wool-cards made thereof, as also hooks and eyes, and other manufactures made of foreign wire. Neither shall any translate and trim up any old wool cards, nor sell the same at home or abroad." Hooks and eyes, although apparently too insignificant an item to have been enumerated in a royal proclamation, were used in such great quantities at the time in question,— as, indeed, they had been long before, — that a vast amount of wire was consumed in their manufacture. They are still largely in demand; and even to the value of these trifling articles, the ingenuity of the Birmingham artists has added much both in beauty and usefulness. The prejudice in favour of musical wire manufactured at Berlin still exists with many instrument-makers, notwithstanding the perfection to which it has been brought by many of our own wire-drawers. Carding machines, on the other hand, so far from being any longer brought from abroad, are strictly prohibited from being exported from this country.

In the seventeenth century the wire-drawing business, following, as it would seem, the woollen cloth manufacture, or perhaps determined by the proximate localities of coal and ironstone, took deep root in the neighbourhood of Barnsley in Yorkshire, the works of which place were long famous for the manufacture of wool-cards: the first workmen, it is supposed, came hither from Wales. Although the celebrity of the Barnsley wire has now yielded to the universal improvement which of late years has characterised the process of drawing, and more especially to the almost total disuse of the common card, there are still some considerable establishments in the vicinity of Wharncliffe, a spot traditionally noted for its "dragon's den," and the magnificent character of its scenery.

Previously to the admirable contrivance of grooved rollers, rods of iron intended for the drawing-mill were hammered out to such length and thickness as might be most convenient for the purpose intended. This iron, being the best and toughest which the native ores yielded, was called asleom or esleom iron, or, as in the act of Charles I., Orsmund iron: it was wrought carefully under the hammer into rods about the thickness of one's little finger, and, after being well annealed, was bundled up and sold to the wire-drawers under the above appellation. These rods were afterwards farther reduced by an ingenious operation, called by the workmen in this country *ripping*, or *rumpling*. Beckmann has a curious notice of the alleged inventor of the contrivance in question. "The greatest improvement ever made in this art," he observes, "was undoubtedly the invention of the large drawing-machine, which is driven by water; and in which the axletree, by means of a lever, moves a pair of pincers, that open as they fall against the drawing-plate; lay hold of the wire, which is guided through a hole in the plates; shut as they are drawn back; and in that manner pull the wire along with them. What a pity, that neither the inventor nor the time when this machine was invented is known! It is, however, more than probable that it was first constructed at Nuremberg by a person named Rudolf, who kept it long a secret, and by these means acquired a considerable fortune. Conrade Celtes, who wrote about the year 1491, is the only author known at present who confirms this information; and tells us, that the son of the inventor, seduced by avaricious people, discovered to them the whole secret of the machinery; which so incensed the father, that he would have put him to death had he not saved himself by flight."

The contrivance mentioned by Beckmann, although now rarely to be seen in the large wire-mills of this country, is still to be met in some of those old establishments where expensiveness, or want of convenience, preclude the adoption of rollers; and where the rippers, as the workmen are called, care little about modern improvements. *Fig.* 109. is a representation of the machine.

Fig. 109.



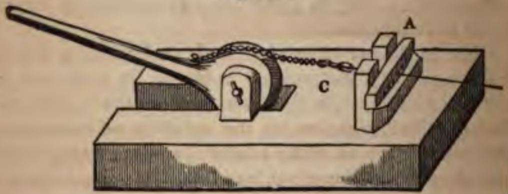
A is an inclined plane, either of cast-iron, or more commonly of wood only, with plate facing: at the lower end is placed the drawing-plate, through which the wire passes. B a jointed shank, terminating at one end as a pair of pincers, and at the other end attached by a rod to the lever C. The tailpiece of this lever is so placed, that on being depressed by every successive stroke of the cam D, the head is drawn backward, and therewith the pincers, thus pulling the wire through the plate. Instantly that the cam has passed the tail of the lever, the head is brought back to its present position, and the nippers advanced to take a fresh hold of the wire by means of an elastic pole placed over head in the mill, and connected by a cord to the lever. In making this return stroke, the shank is prevented from expanding too much; and the direction of the pincers at the same time rendered more exact by the rising edges of the inclined plane. In some of these machines, the pincers, instead of the expanding shank, are of a more simple form, and are made to move in the direction of the drawing plate, by means of a groove running along the inclined plane.

In France, and among the continental manufacturers generally, iron-wire was, until within a late period, altogether drawn by the operation above alluded to; and which, however ingenious and useful, is essentially defective, especially in the drawing of the finer sorts of wire, — every piece exhibiting, at intervals of a few inches, the marks of the pincers. Besides, not only is the wire drawn by a succession of jerks, and, therefore more or less unequal in surface, but considerable time is lost between each draw-stroke and the return of the pincers; to say nothing of their occasionally missing their hold upon the wire.

As already intimated, wire, whether of iron or steel, more particularly the former, is now almost exclusively prepared for the drawers by the operation of passing it between grooved rollers; and there are few exhibitions of the effect of machinery upon metal which are more striking at first sight to a stranger, than the promptness and facility by which a slender string of iron is spun, as it were, out of the stubborn bar. The rollers used for this purpose are of course either turned or cast with hollows on their peripheries, larger in the first instance to receive the bar, and gradually diminishing in size until they answer to the thickness of the rod intended to be produced. These rollers, which are generally at the least seven or eight inches in diameter, are sometimes made to perform 350 revolutions in a minute. A bar of steel, about one inch square, and thirty inches long, is drawn out of the heating furnace at a strong red heat, and passed between these rollers eight times in less than a minute, during which it is elongated to from twenty to forty feet. To facilitate the production of a piece of wire of this length, and the whole of which it would be less easy to transfer from that side of the machinery where it is extruded to that where it is again inserted, than is the case with an inflexible rod, or even a sheet of metal, modern ingenuity has devised the expedient of a third roller; so that the wire, on making its appearance from the upper cavity, is instantly caught and inserted in the under groove, by which means it is rolled and reduced, in both directions, without loss either of time or of heat. When thus prepared at the rolling-mill, and generally found to be about the eighth of an inch in diameter, it is laid in coils, and subsequently sold to the wire-drawers, by whom it is reduced to every variety of smaller sizes. Cast-steel wire, of which the best needles and some other articles are made, is still commonly tilted to about a quarter of an inch square, and afterwards rounded on the anvil, previously to its ultimate elongation by means of the drawing-plate.

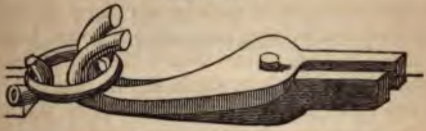
Wire is drawn either by hand, or by steam, water, or other power; the process, however, in each case is nearly the same, with the exception of the means applied to give revolution to the cylinder or reel, upon which the wire is wound after passing through the drawing plate. This plate, as it is called, is generally a stout piece of the best shear steel, about six inches in length, an inch and a half in diameter, and of a roundish or cucumber form, with the exception of one flat face. The holes through which the wire is drawn are punched, in a tapering form, from the flat side, where they are left much wider, to receive the wire, than they are at the orifice in front, whence it issues, and by means of which the appropriate reduction and elongation are mainly effected. In some of the scientific periodicals has appeared the following "mode of making Italian wire-drawing plates:" — A piece of plate iron is formed into a sort of shallow box or tray, its edges being bent, or turned up at right angles all round. This case is then filled with broken pieces of cast-iron, and heated to a welding heat, when it is well hammered and firmly united to the iron. The holes are then punched through it from the back, the face of it being thus formed in the cast-iron. Whatever the Italians may do, it is quite certain that no English wire-drawer would be able to compose a plate after this fashion. The notion of uniting pieces of cast-iron by welding, in the manner alluded to, is incompatible with the slightest knowledge of the condition of the metal; to say nothing about the comparative value of a draw-plate so composed, and of such materials, and one made of the best steel. To get the end of the stronger descriptions of wire through the plate, and extend it sufficiently to allow it to be attached to the drawing cylinder, a lever, a good deal resembling the handle of a pump, is used (*fig.* 110.).

Fig. 110.



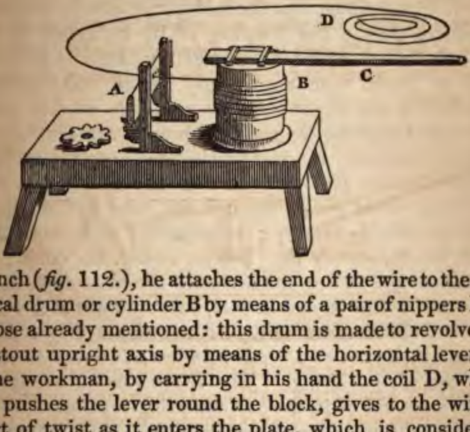
The point of the wire, after being sharpened to som distance by hammering or filing, is inserted through o of the holes, and the drawing-plate placed behind t stout iron pins, in the bench at A. The handle B then raised, and the nippers C, at the extremity o short chain, are made to pinch the point of the w which, by depressing the lever, is pulled through the plate to a considerable extent: this operation is repeated, until a sufficient length of wire for the purpose has been obtained. The nippers (*fig.* 111.) are made to grip, by means of a ring passing over their shanks, and attached to the chain, so that the stronger the pull the firmer the hold.

Fig. 111.



The workman now takes the coil of wire in his hand, and placing the drawing-plate against the props A on the bench (*fig.* 112.), he attaches the end of the wire to the conical drum or cylinder B by means of a pair of nippers like those already mentioned: this drum is made to revolve on a stout upright axis by means of the horizontal lever C. The workman, by carrying in his hand the coil D, while he pushes the lever round the block, gives to the wire a sort of twist as it enters the plate, which is considered necessary to the operation. These plates, when of a good material, although not hardened, will draw down a piece of steel wire some scores of yards in length,

Fig. 112.



without the holes suffering any perceptible increase of size: when, however, any enlargement does take place, or when any reduction is required, the orifice is merely knocked up in front by hammering, and then rounded and brought to the proper size by the introduction of what the workman calls a *pritchel*, or long taper needle, after which the plate is levelled and again ready for use. Hardened steel plates are sometimes used, when the wire is wanted very stiff.

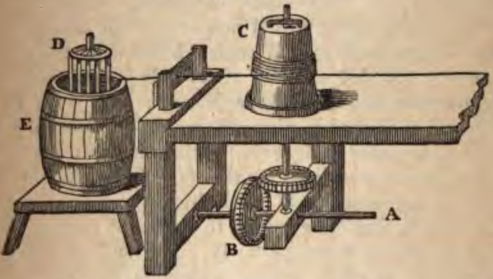
During the operation of reducing the wire, in consequence of its becoming very stiff and hard after passing through the plate, it requires to be repeatedly lighted or softened. This is done by heating it red-hot in a close furnace; after which it is placed in a vessel containing an acid liquor: this immersion causes the scale produced by the heating to come off, on the wire being afterwards laid in stale wort, or the grounds of ale, and then well scoured previous to its further reduction. The Mechanics' Magazine mentions, that the acid liquor used in pickling iron-wire, during the drawing of it, requiring to be warmed, at an eminent manufactory, ingots of brass lying at hand were accordingly heated red-hot and quenched in the liquor; the consequence of this was, that a portion of the copper in the brass became dissolved in the menstruum, and was precipitated upon the surface of the iron-wire pickled in it. It was found that the wire thus coated passed through the holes in the plates with remarkable facility; it requiring to be annealed much less frequently than before, owing, no doubt, to the copper preventing the action of the plate upon it, so as to gall or fret it, and in fact, lubricating it as it were. The head of this manufactory has since constantly availed himself of the use of a weak solution of copper in iron and steel wire-drawing. The slight coat of copper is entirely got rid of in the last annealing process.

When the wire becomes so fine that little power is required to draw it, instead of the low bench, long stout lever and large drum—the workman travelling once round the bench with every revolution of the drum—

the coil of wire is placed upon a reel, adjoining to which stands a winding cylinder of iron, exactly similar in shape and position to B, (*fig.* 112.) but which has a horizontal handle at the top of it, which, sliding through two flat staples, admits of being drawn out to increase its power, or pushed back when greater speed is sought. By means of this handle the drawer winds the wire from the reel to the cylinder with the utmost facility; its friction in the plate being so trifling as hardly to be felt.

When the manufacture is conducted on a large scale by means of steam or other power, a number of metal winding cylinders are placed beside one another along a stout bench, in the manner of the one represented in the subjoined delineation (*fig.* 113.).

Fig. 113.



A is the horizontal shaft connected with the moving power, and having at B a bevel wheel, which takes into the teeth of a similar wheel on the upright spindle carrying the drum or cylinder C. The upper end of this spindle is a small cross-bit, with prongs downward that fit into corresponding holes in the top of the cylinder, in such a way that, while the whole is kept tight by the passing of the wire through the draw-plate, the cylinder retains its position: but as soon as the wire is entirely drawn off the reel D, and has passed through the plate, the cylinder, becoming loose at the top, drops down upon the bench, the spindle alone continuing to revolve. The coil of wire is now taken off the drum; and a fresh reelful being set in the place of the other, the end of the wire, sharpened for the purpose, is pulled through one of the holes in the draw-plate and attached to the cylinder. The cylinder is then lifted a little, so as to assume its former position in contact with the clutch, upon which it immediately revolves, and the operation goes on as before. The tub E contains starch water, or stale beer grounds, in which the wire on the reel is immersed during the operation, and the effect of which is to remove the oxide that may adhere to the surface.

As an ingenious suggestion connected with the art of drawing fine wire, especially that of the precious metals, it may be mentioned, that in 1819 a gentleman of the name of Brockedon got a patent for making wire drawing plates of "diamonds, sapphires, rubies, chrysolites, or any other fit and proper gems or stones:" in these he proposed to drill conical holes with their extremities rounded off, and afterwards polish them by the processes known to the lapidaries; they were then to be set or framed in plates of metal or other fit substances, in order to fit them for the wire-drawer's use. The advantages claimed for this fanciful application of precious stones in lieu of steel draw-plates by the inventor were, that "they afford the means of making each wire so drawn more perfectly equal and cylindrical throughout its whole length, owing to the hard substances in which the holes are made, resisting the friction of the metal in passing through them; whilst, at the same time, the holes themselves are less liable to become galled or enlarged by the passage of the wire than those made in metal plates."

The following account of the method of preparing French wire-drawing plates, and of drawing iron and steel wire in one of the largest establishments in France, is derived from Nicholson's "Operative Mechanic." The French draw-plates are highly esteemed, and, in time of war, a good French draw-plate has been sold for its weight in silver. M. du Hamel, in his *Arts et*

Metiers, vol. xv., gives the following account of the process of making the draw-plates for the larger iron-wire : —

A band of iron is forged of two inches broad and one inch thick. This is prepared at the great forge. About a foot in length is cut off, and heated to redness in a fire of charcoal. It is then beaten on one side with a hammer, so as to work all the surface into furrows or grooves, in order that it may retain the substance called the potin, which is to be welded upon one side of the iron, to form the hard matter through which the holes are to be pierced. This potin is nothing but fragments of old cast-iron pots; but those pots which have been worn out by the continued action of the fire are not good; the fragments of a new pot which has not been in the fire are better.

The workman breaks these pieces of pots on his anvil, and mixes the pieces with charcoal of white wood. He puts this in the forge, and heats it till it is melted into a sort of paste: and, to purify it, he repeats the fusion ten or twelve times, and each time he takes it in the tongs to dip it in the water. M. du Hamel says, this is to render the matter more easy to break into pieces.

By these repeated fusions with charcoal the cast iron is changed, and its qualities approach those of steel, or rather it should be said it becomes steel; but, far from becoming brittle, it will yield to the blows of the hammer and to the punch, which is used to enlarge the holes. The bar of iron which is to make the draw-plate is covered with a layer of pieces of the potin or cast iron thus prepared. It is applied on the side which is furrowed, and should occupy about half an inch in thickness. The whole is then wrapped up in a coarse cloth, which has been dipped in clay and water, mixed up as thick as cream, and is put into the forge. The potin is more fusible than the forged iron, so that it will melt. During this fusion the plate is withdrawn from the fire occasionally, and hammered very gently upon the potin to weld, and in some measure amalgamate it with the iron, which cannot be done at once; but it must be repeatedly heated and worked, until the potin fixes to the iron. The workman then throws dry powdered clay upon it, in order, they say, to soften the potin.

The union being complete, the plate is again heated and forged by two workmen, who draw out the plate of one foot to a length of two feet, and give it the form it is to have. It is well known that cast iron cannot be worked at the forge without breaking under the hammer; but in the present instance, it is alloyed with the iron bar, and is drawn out with it. It has also acquired the property of malleability, which belongs to steel by the repeated fusions with charcoal.

The holes are next pierced whilst the plate is hot. This is done with a well-pointed punch of German steel, applied on that side of the plate which was the iron bar. It requires four heats in the fire to punch the holes, and every turn a finer punch is employed, so as to make a taper hole. The makers of draw-plates do not pierce the holes quite through, but leave it to the wire-drawers to do it themselves, when the plate is cold, with sharp punches, and then they open the hole to the size they desire; and although this potin is of a very hard substance, the size of the hole may be reduced by gentle blows with a hard hammer on the flat surface of the plate round the hole.

A great many holes are made in the same plate, and it is important that they should diminish in size by very imperceptible gradations; so that the workman can always choose a hole suitable for the wire he is to draw, without being obliged to reduce it too much at once.

The wire manufactory of Messrs. Mouchel, situated at L'Aigle, in the department of L'Orne, is one of the most considerable in France. It furnishes annually in cards for wool-combing alone 100,000 quintals of iron wire, each 100 lbs. A part of this is consumed in

France, and the rest is exported to Spain, Italy, Portugal, and even to the shores of the Levant.

They employ the iron manufactured in the department of L'Orne and La Haute Saône, as being of the best quality. The first produces the best wire for making screws, nails, and pins, as much on account of its hardness as its fine polish, which resembles steel wire: in this respect it is superior to the iron of Haute Saône; but from its ductility the latter can now be made extremely fine, and it appears to be most free from heterogeneous particles.

The smelted iron, prepared and hammered, being in a state nearly fit for their purpose, is transported at a small expense to L'Aigle, by the rivers and canals. They have a forge to reduce the steel and iron of Normandy, which arrives in large pieces, into small and regular bars.

When the iron is formed into an irregular bar of about a centimètre (near four tenths of an inch) in diameter, they begin to draw it into wire. Although it be already much extended by hammering, it is in the first place passed four times through the drawing-plate; then its molecules become disposed lengthwise, and exhibit fibres at their utmost extension. The fibres must be removed by means of heat, which disperses and divides them; and after that, the wire may again be reduced three numbers. The fibrousness produced by this operation is again removed by means of heat. The whole process is five times repeated; consequently the wire is passed through fifteen numbers, after which, a single exposure to the fire is sufficient to fit it for passing through six others, whereby it is reduced to the thickness of a knitting-needle.

The steel wire being much harder, requires to be passed through forty-four numbers, and to be annealed every other time.

The machine which draws the steel-wire must go slower than that which draws the iron; for the first, being very hard, and offering more resistance to the drawing-plate, should be pulled out with more care, since the quickness ought to be proportioned to the resistance, and reciprocally; and if they depart from this principle, the results will vary. Thus, for example, the iron of the department of L'Orne, which is more compact than that produced at Haute Saône, if drawn by the same machines, augments to hardness, and is weakened when it is brought to too great a degree of fineness. But this iron, which is very hard, and capable of receiving a very high polish, is to be preferred for certain uses.

In order to anneal the wire, they formerly employed a large and elevated furnace, with bars of cast iron to support the wire in the middle of the flames. It contains 7000 pounds' weight, so contrived as to contain equal portions of each number. They are so arranged that the thickest wires receive the strongest heat, therefore the whole is equally heated in the same space of time.

The operation lasts three hours with a fire well kept up, and it might be imagined that this apparatus was completely adapted to the purpose; but there are imperfections in this method, because it leaves the wire exposed to the contact of the atmospheric air, the oxygen of which it seizes with extreme avidity, whence a considerable quantity of oxide is occasioned, and also an operation to free it from the scales, which consists in beating the bundles of wire with a wooden hammer, wetted with water.

Notwithstanding this precaution, there often remains a portion of oxide adhering to the surface of the metal, which streaks the draw-plate or fixes on the wire, and gives it a tarnished appearance, and even causes it to break when brought to a great degree of fineness. This furnace is only used for the steel wire, or the iron from L'Orne, which is less liable to change; and, besides, being harder, is not easily attacked by the oxygen.

In order to diminish the waste that the fire occasions, they have contrived another process, which consists in dipping the bundles of wire into a basin of wet clay before they put them into the furnace; and they are left in the furnace to dry before the fire is lighted, without which precaution the clay would peel off from the iron.

For annealing the wire used in the manufacture of cards, MM. Mouchel invented another furnace. It is round, and about one mètre six decimètres in diameter, and one mètre eight decimètres in height, without including its parabolic arch and the chimney above it. The interior is divided, by horizontal grates, into three stories; the lowest receives the cinders, the second is the fire-place, and into the third, or upper place, they slide a rouleau of wire, weighing 150 kilogrammes, which is enclosed in a space comprised between two cast-iron cylinders; being luted, to prevent the admission of air between them. The flames circulate about the outside of the first, and within the interior of the second, which defends the wire from atmospheric air. The diameter of the largest cylinder is about one mètre four decimètres; that of the second one mètre: thus the space comprised between them is two decimètres on an elevation of five decimètres. There must be several pairs of cylinders provided; because, whilst one pair is in the furnace, another must be prepared to receive a fresh rouleau of wire: they are changed every hour by means of a long iron lever, with which a single man can easily push them in and draw them out again, as the cylinder slides on cast-iron rails.

They are very careful not to open the cylinders immediately on their being drawn out of the fire; for the rouleaus of wire contained in them, being still red, would oxidate quite as much as if they had been heated in the midst of the flames without the least precaution.

The opening contrived for the passage is on the side, and has a door of cast iron, with a groove which winds round the furnace; the fire-place has one something similar to it; that of the ash-hole is vertical, in order that it may be raised, to increase the fire, at will.

When the iron wire is reduced to the thickness of a knitting-needle, it is made up into bundles of 125 kilogrammes (275 lbs.) each, into a large iron vessel, in order to anneal it sufficiently to be reduced for the las time. This vessel is placed, mouth downwards, in the middle of a round furnace, which is so constructed as to sustain burning coals all around it, and of which it consumes 35 kilogrammes (77 lbs.) before the operation is completed. The cover must be carefully luted, as the slightest admission of air is sufficient to burn the external surfaces of the wire to an oxide, which cannot afterwards be reduced.

When one of these vessels is sufficiently heated, it is filled with water, containing three kilogrammes (six pounds and a half) of tartar, and suspended over the flames of the furnace to make it boil. This solution, without attacking the metal, frees it from the grease and the little oxide that adheres to it. This is the last operation in which the wire is exposed to the fire; and it is then in the proper state for being reduced to the utmost degree of fineness it is capable of sustaining, and will preserve enough of the effect of the annealing to require it no more; but when the natural hardness of the iron varies, this last exposure to the fire should take place in proportion to its thickness. As steel loses its capacity of extension much sooner than iron, it is annealed till it is no thicker than a sewing-needle. The space which is left in the vessel is filled up with charcoal dust, which prevents it from losing the quality o steel, and preserves the heat long enough to give it the proper degree of pliancy.

As Messrs. Mouchel always use iron and steel at the same manufactory, they have been able to reduce their operations to a general system; and, to attain this end, have determined a graduated scale, by which the wire will not be more stretched in the drawing plate in one number or size than another. The following is the method they contrived in order to form this scale for the iron wire:—They take a certain quantity, of various thicknesses, which has been drawn as fine as the iron would bear: the smallest size is 100,000 mètres (109,303 yards) in length to the kilogramme (2·2 pounds avoirdupois); they note the weight that each might be capable of supporting without breaking: this being expressed by figures, it is easy, by a few interpolations, to express them in a progressive form. This kind of scale has been partly formed by comparing the weight of the different sizes with equal lengths, from which gauges or calibres may be made for the use of the workmen. These gauges are certain guides, which they cannot mistake, except through great carelessness. If they had not these gauges, they would often pass the wire through holes in the drawing-plates that are too large for it, whence it does not acquire the strength it should have in proportion to its thickness, and loses its hardness; they might also pass it through holes that are too small, which would weaken it, and render it very brittle. In the latter case, it frequently happens that the steel of the drawing plate, being unable to sustain the force to which it is exposed, will give way, as if the plate were too soft; and the wire will be brittle at the beginning, and soft and too thick at the other extremity.

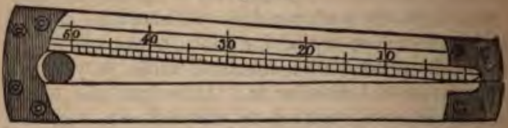
The greater part of the fine wire at Messrs. Mouchel's is hand-drawn by workmen dispersed about the country; but they have also a machine which moves twenty-four bobbins in a horizontal direction, which only requires the workmen to look after it. It is upon the bobbins that the wire is reduced to the different degrees of thinness desired; therefore this is the last operation in the art of making iron and steel wire, although it has all requisite qualities given to it in the workshop of the wire-drawer.

Wire is still incapable of being manufactured into needles and carding-hooks until it has undergone another operation for dressing and straightening, by which it is made to lose the bend or curve that it acquires on the bobbins.

This operation consists in drawing the wire between pins fixed in a piece of wood, and which act to bend or set the wire, first in one direction, and then in the other, in a waving line, of which the flexures are, at first, longer, but decrease gradually, and the last direction of which tends to force the wire into a straight line.

Wire is gauged, or the diameter of each sort ascertained, with a sufficient degree of nicety for most practical purposes, by inserting it into a nick filed in the margin of a steel plate containing a gradation of these nicks or grooves, numbered from one to thirty, beginning, in some gauges, with the smallest size, and in others with the largest. The most carefully graduated and reputable of these wire-gauges are those manufactured by the Messrs. Stubs of Warrington. Of these, the largest sized aperture is $\frac{3}{16}$ and the smallest $\frac{1}{100}$ of an inch. As, however, there is no certain and universal principle upon which the scales of all the wire-gauges made in this country are laid down, disagreements and difficulties occasionally arise. In order to remedy that inconvenience, the gauge here represented has been proposed to the Society for Promoting the Useful Arts in Scotland.

Fig. 114.



The inventor says,—"In the gauge most generally used, wire of about ·31 of an inch diameter is called No. 1., nd the sizes decrease to No. 26., which is under ·02 of an inch. Some classes of artists use gauges in which No. 1. denotes the smallest size, the dimensions increasing with the numbers. In the first case, wire thicker than

No. 1. can have no name; and in the latter case, the reverse obtains. In both cases, it is found in practice, that corresponding numbers in gauges (which profess to be similar) often differ very materially; and an artist who may order wire from the manufacturer by a number is liable to find that the gauge used by the latter may differ a size or more from his own. With a view to do away with these inconveniences, and to obtain some advantages, it is respectfully proposed to the society, to sanction, by their recommendation, the establishment of such a standard gauge as may be easily and accurately made by any tolerable workman, of which all copies must tally with one another, and in which the numbers may denote the actual diameters of the wire. To fulfil these conditions, all that is required is to take two straight rulers (of any convenient length), to make their edges touch at the one end, and to separate them *near* the other, by a cylindrical or spherical body, of half an inch diameter. If the rulers be unalterably fixed in this position, and the space lying between the points of contact with the cylinder at the one end, and of the rulers at the other, be divided into fifty equal parts, and numbered from 50 down to 0, then the divisions will show the diameters of wire in hundredths of an inch. If the dispart, instead of being made ·50, is made ·05 hundredths, then the divisions would show thousandths, which would make a convenient gauge where fine wire should be most used. The three faces of the rulers which remain unoccupied by the standard scale may be furnished with divisions and numbers, formed from any of the gauges at present in use, which would enable artists to ascertain sizes, according to both the present and the proposed scales at the same time." Along with this communication, the inventor transmitted to the society a gauge, made on this principle, of two steel rulers, riveted at the ends to clips of brass, and which is represented by the foregoing figure. For the convenience of gauging wire in bundles, it is recommended that the instrument be left open at the wider end.

It has, however, been justly objected against the superiority of this gauge, that it will not ascertain the full and exact diameter of the wire at the *tangible points* of the two sides of the gauge, which circumstance must, indeed, be apparent on an inspection of the preceding cut. It must be admitted, however, that this peculiarity need not affect the utility of the instrument, provided it be marked with strict mathematical allowance for the error; so that each mark should stand on the *true diameter* of the wire, instead of at the points where it must touch the gauge.

Besides the round wire of all sizes, and which is used for so great a variety of purposes, the pinions of watches and those used in almost all kinds of minute rackwork, are made from wire drawn through a steel plate, having holes of a size and figure corresponding with the nature of the work. In this manufacture, the leafage of the wire is produced by passing it through a numerous succession of rayed perforations, each one deeper than that preceding it, until the last perfects the article. In drawing pinion wire, not only is the greatest care and exactness required, in order that the workmanship of many hours may not be utterly lost by some mischance near the finishing, but the operation is performed by means of a long rack, which admits of the wire being grooved and perfected, quite straight, in pieces of a reasonable length. Wire is drawn grooved for other purposes: the loop of metal that surrounds the glasses in spectacles, for instance, is composed of wire of this description.

CHAP. XVI.

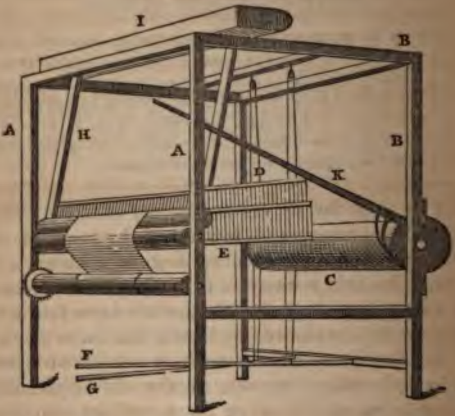
WIREWORKING AND NEEDLES.

DESCRIPTION OF WIRE LOOM, AND METHOD OF WEAVING. — WIRE GAUZE, ITS USES. — WIRE FOR CARDS. — SELF-ACTING MACHINE FOR MAKING CARDS. — WATCH-SPRINGS. — NEEDLES. — SEATS OF THE MANUFACTURE. — CUTTING AND STRAIGHTENING THE WIRE. — POINTING. — EYEING AND FILING. — SOFT STRAIGHTENING. — TEMPERING. — HARD STRAIGHTENING. — SCOURING. — SORTING. — BLUE POINTING.

WIRE is used for an endless variety of useful and ornamental purposes, and hence the business of wireworking gives employment to a great number of individuals in this country. In giving to wirework the form of meshes, the material is either woven in a loom or ingeniously implicated by hand; the latter being the process when the apertures are as much as an inch in size, or otherwise than rectangular: the operation of weaving is resorted to when the set of the web is from three fourths of an inch to forty meshes in the inch. The annexed cut is a representation of the wire-weaver's loom.

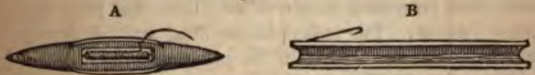
A A, B B (*fig.* 115.), the frame of the loom, about five feet high, four feet deep, and three feet wide; these dimensions, however, differ much in different looms; some of those for weaving the material used in making moulds for the paper mills being sometimes six or seven feet wide. C, the beam, or wooden roller, which is turned with a succession of deep grooves, into which the warp is wound, each groove receiving a greater or less number of wires, according to the fineness of the fabric. These wires pass through the gearing, D E, between the bars of a reed, as in linen-weaving, over a roller in front of the frame, and, finally, down to another cylinder, upon which the web is at intervals wrapped as the work proceeds. The heddles, or gearing, D E, consists of two sets or four frames filled with vertical wires, each about the thickness of a common knitting-pin: in the middle of each of these wires a small hole is punched; through these perforations every single wire of the before-mentioned warp is separately carried. These sets of gearing are suspended, two and two together, by cords passing over the top of the loom, and connecting with the two treadles, F G, on the floor. The whole of the warp being distributed in this way, it will be obvious that, by pressing the treadles alternately, the warp-wires in frames D and E will be in succession elevated and lowered, so as to afford a passage for the shuttle containing a bobbin of wire to form the weft of the web: this wire having been thrown across, it is driven up by a stroke with the reed, which swings in the lower part of the lever H: the warp-wires being made to change positions by means of the treadle, another cross-wire is thrown, and knocked close to the former by means of the reed; and this operation is repeated until the web is finished. The reed is composed

Fig. 115.



of small bars of steel-wire, set as close as possible, so as to admit the warp: the swing frame H, to which it is attached, is itself balanced by means of the heavy movable piece of timber I, which rests on two pivots on the top of the frame. When the web is sought to be wrapped on the front roller as the work advances, the beam C is moved a little about by means of a rachet wheel at one end, and the connecting lever K. The shuttle A (*fig.* 116.) is not very dissimilar to that used by the old linen-weavers; it is a sort of obtuse needle, made of boxwood, about six inches long, with an aperture in the middle for the insertion of the bobbin. When the meshes are large, and the wire too strong to be drawn off a bobbin, it is wrapped lengthwise upon a notched stick B (*fig.* 116.), by means of which it is carried through the warp. Wire, as well as threads of animal and vegetable matter, is woven by machinery impelled by steam; and in 1830 a patent was granted to J. R. Williams, esq., for improvements in power looms for weaving wire.

Fig. 116.



The finer descriptions of woven wire are mostly used in large quantities for flour-dressing machines, paper-mill washers, and other like purposes; the coarser sorts for fences, pheasantries, riddles, lanterns, &c. A transparent wire gauze, handsomely painted in figure-work, has lately been introduced into the manufacture of window blinds; and the appearance of which, when tastefully got up, is very satisfactory.

It is now generally known that wire gauze, notwithstanding the perforation of its texture, possesses, to a very considerable extent, the property of intercepting the effects of flame, as any person may easily prove, by holding a piece of this fabric between his face and the blaze of a large lamp. The knowledge of this extraordinary property suggested to chevalier Aldini, a Milanese, the possibility of making out of woven wire a dress or armour which should be so far fire-proof as to allow a person protected by it to expose himself in situations otherwise inaccessible. Several striking and satisfactory experiments as to the trifling effect of intense flame upon individuals so habited were made in Paris and London, and the application of the material for this purpose in the case of accidental fires has been largely recommended. The gold Isis medal of the Society of Arts was presented to chevalier Aldini for this wire-gauze armour. The most philosophical and triumphant application of wire-gauze in the preservation of life has, however, been achieved by our countryman, sir Humphry Davy, in the invention of the miner's safety lamp. It is true the main principle of this invaluable article depends, for its investigation, rather upon a profound knowledge of the theory of combustion than upon any understanding of the wireworker's art; but the latter is so essentially conducive, mechanically at least, to the production of the phenomena of the discovery, that no apology can be necessary for enriching this page with the name of one of the most illustrious promoters of philosophical science which this age has produced.

The various descriptions of wirework in which the open spaces are of fanciful forms, require to be carefully implicated by the hand; and the perfection of the fabric which is thereby produced depends greatly upon the dexterity of the artist.

Iron wire, as we have already had occasion to state in the preceding chapter, derived its principal value in the estimation of the legislature, in 1630, from its entering so conspicuously into the manufacture of cards for dressing wool. On this point the jealousy and vigilance of successive governments have been unremitting, and doubtless, on the whole, wisely so, notwithstanding the occasional inconveniences and losses to which individuals and, perhaps, the country, may at times have been subject from the working of the system. Mr. Farey, engineer, mentioned in his evidence on the patent laws, delivered before a committee of the House of Commons, that a self-acting machine was invented in England thirty years ago, for making wire cards for preparing wool and cotton: it bended and cut the wires, pricked holes in the leather, and inserted the bended teeth into these holes by one operation, without manual labour: a patent was taken out for the invention by Messrs. Thorp and Whittemore, in 1799. The machine was very ingenious, and was made to operate with rapidity; but the cards produced by it were too coarse and imperfect to be used with advantage in this country, where the art of card-making by hand had previously been brought to great perfection; the inventor, therefore, carried his machine to America, where coarse cards were more in requisition; and as our laws prohibited the exportation of any of our cards, the want of efficient card-makers in America rendered a self-acting machine of value there, although not very perfect in its operation. He succeeded in America so far as to carry on a trade, and, by practice, improved his machinery till it supplied the American demand very well. A Mr. Dyer, who was at this time a merchant, became acquainted with the invention, and, thinking it had attained a state of perfection sufficient to be re-exported with advantage to England, he purchased the invention, and came over here to take out a patent when the original patent was nearly expired. Mr. Dyer ultimately began a manufactory at Manchester. When the cards manufactured by this machinery began to be sent out to the cotton and woollen mills, they were found still too coarse and imperfect for efficient use in England; and Mr. Dyer, though not originally a mechanician, set himself to study the subject, until he was able to improve the machinery, and make saleable cards by it. His first set of machines were destroyed by fire at an early period of his settling at Manchester, and he lost much property; but, in the end, that circumstance ensured his success, because he made entirely new machines, with many improvements that he had found out before the fire, but which could not have been applied with so much perfection by altering the original machines as in making new ones. He was obliged to take another patent for these improvements, and he has had other patents since; and has established a considerable trade with great advantage.

Both the main and the hair springs of watches are made of steel first drawn into wire. In the former description of spring, the workman gives to the material its wonderful elasticity, by hammering it out upon an anvil; it is then ground, hardened, coiled, and tempered by bluing as we see it. The manufacture of the latter article has frequently been selected as an illustration of the extent to which the value of a material of small intrinsic worth may be raised by the application of industry and ingenuity. "A pound of crude iron costs one halfpenny; it is converted into steel; that steel is made into watch-springs, every one of which is sold for half-a-guinea, and weighs only the tenth of a grain: after deducting for waste, there are in the pound weight 7000 grains; it, therefore, affords steel for 70,000 watch-springs, the value of which, at half-a-guinea each, is 35,000 guineas!"

Needles.

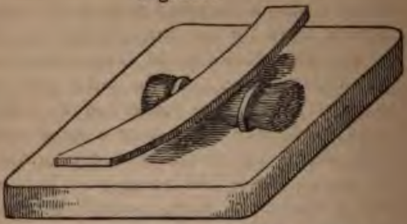
One of the most ancient and lucrative sources of ingenuity and industry, as depending upon the manufacture of steel wire, is the needle trade, so successfully carried on in this country. Workmen in general have some traditions of those who first pursued like avocations with themselves, whether or not history may be silent on the subject. In reference to the present case, our English chroniclers record that "the making of Spanish needles (as the fine sewing-needles were formerly designated) was first taught in Englande by Elias Crowse, a Germaine, about the eighth yeere of Queene Elizabeth; and in Queene Marie's time there was a negro made fine Spanish needles in Cheapside, but would never teach his art to any."

Although at present the needle trade in this country is not by any means so localised as might be supposed, the places most noted for the manufacture are, Whitechapel in London, Redditch in Gloucestershire, and Hathersage in Derbyshire. At the latter place, amidst some of the most picturesque scenery of the celebrated High Peak, the Messrs. Cocker have a large establishment, which affords the means of a comfortable subsistence to numerous of the villagers. This seat of the needle manufacture is more particularly alluded to, because the writer of these pages was not only indebted to the civility of the Messrs. Cockers, for that free ingress to the several departments of their large establishment, and that ready explanation of different processes upon which the accuracy of the following details has no doubt so much depended, but because the remote and mountainous village of Hathersage happily shows how much may be done to improve the social condition even of such a place, by men whose views extend beyond the penurious policy of getting as much as possible out of the labourer, and caring less than nothing about the morals of their work-people.

Cutting and straightening the wire. — A coil of soft, clean steel wire is cut with a pair of large shears into lengths of four or five inches; each piece of wire will make, when again cut, more or fewer needles according to the size intended. These lengths are then bundled together by being placed as compactly as possible within two iron hoops or rings about four inches in diameter; in this state the bundle is placed upon a cast-iron table (*fig.* 117.), and a slab of iron about two feet in length, and broad enough just to fall between the rings, is placed upon the wires, and the bundle rolled backward and forward, the workman pressing with the lever, until the wires become perfectly straight. This operation, which is called rubbing, straightens the lengths perfectly.

Pointing.—Needles of all sorts are pointed upon small grindstones running dry; between one and two dozens of the lengths just mentioned being applied at once with great dexterity by the grinder, each wire revolving while in contact with the stone. In consequence of the minute particles of steel which are evolved in a cloud during this operation, and which are necessarily inhaled by the workman, needle grinding is found to be an employment extremely prejudicial to health. Of late years, however, various devices have been adopted for diminishing the evil, such as hanging a cloth over the stone, so as to draw off the greater part of the pulverulent atmosphere, wearing damped gauze over the mouth, or by placing a mask of magnetic gauze before the face, so that the floating metallic particles are arrested and detained; the needle pointers, however, like the fork grinders, who, as we have elsewhere stated, suffer dreadfully, and often fatally from the same evil, manifestly exhibit rather a reluctance than a forwardness to adopt any preventative which seems to be an incumbrance, and which they oddly enough fancy might tend to abridge the amount of their earnings in the ratio that it should diminish the deleterious nature of their occupation. "Because," say they, "if our work were less injurious, our masters would reduce the prices of grinding." The wire, when pointed, is again cut with shears into bits of the exact length of the intended needle.

Fig. 117.



Eyeing and Filing.—To perforate a bit of exceedingly fine steel wire so as to produce the eye in a needle hardly the thickness of a hair, must obviously require a hand possessing at once considerable delicacy and dexterity combined. The person, generally a female, performing this operation, first slightly flattens with a small hammer that end of the needle intended to receive the eye; she then places it upon a little anvil which is fixed in her work-bench, and by means of a stroke with her hammer upon a delicately pointed steel punch makes an indentation on one side; she then places it upon a block of lead, and by a similar stroke with the same instrument completes the perforation. The needle is in the next place detained in a pair of pliers, and the head being bent back a little, it is by means of a suitable kind of file made to receive that peculiar channel or gutter which is observable on each side of the eye; this *guttering*, as it is called, is performed with amazing precision and despatch by some women: a smooth file is afterwards applied upon the head of the needle. These processes are generally conducted by outworkers — women and girls at their own homes, and are mostly confined to the more delicate articles. The larger needles are brought more directly under the operation of machinery. For instance, the formation of the gutters and the piercing of the eye are made to depend upon strokes given by a stamp and a fly press. In the former process, a piece of wire of the length of two needles, and pointed at both ends, is placed exactly in the middle upon a steel die having the form of the gutter, &c. impressed on its surface: over this die hangs another, its exact counterpart; so that by means of a blow from the stamp hammer, the two needles between the dies are exactly impressed on both sides with the channels already mentioned. The piece of pointed wire is then in a similar manner placed under a fly press, where, by means of two steel points falling over corresponding holes in a die, the two eyes are instantly pierced with great precision. These needles are then broken asunder, and the heads corrected with the file, as in the former case.

Soft Straightening. — During the foregoing operations the needles have severally become more or less crooked, especially in the guttering by hand, when the head is pushed or bent backward and forward for the convenience of the file. To correct this defect, the needles are placed in files on a smooth metal plate, and by means of a piece of smooth iron, like that above described, they are rolled until they become severally quite straight.

Hardening and Tempering. — The needles are placed, several thousands together, in a cast-iron receptacle; and, after being covered over with ashes, to prevent oxydisation, they are submitted to the heat of a close furnace, until reaching a cherry red, the vessel is withdrawn and its contents dropped into a tub of cold water; they are then collected from the water and placed upon an iron plate, kept nearly red-hot by means of a fire underneath. Upon this plate the workman, by means of two little iron shovels, keeps turning the lot of needles inside out, as it were, so as to allow the effect of the heat to take place upon them all equally. As soon as the blue oxydisation makes its appearance the needles are considered of the proper temper, when they are instantly removed, with singular dexterity, by means of the two spatulæ just mentioned.

Hard Straightening. — As almost all kinds of steel articles, if light and slender, are found to suffer some alteration of shape during the process of hardening, so needles, in this stage, are more or less warped or bent; they are severally, therefore, straightened by means of two or three strokes from a small hammer on a little anvil fixed in the work-board for this purpose. They are now ready for

Scouring. — This operation requiring considerable force is in all cases performed by water or steam power. The needles are placed neatly one over the other, many tiers deep, and in parallel rows, upon a piece of stout coarse cloth smeared over with oil, soft soap, and fine flour emery; the cloth is then rolled up, so as to enclose the needles, much in the same way as certain Yorkshire housewives are in the habit of interlaying preserved fruit n lamina of paste for family dumplings: the rouleau is now tied about firmly, throughout its length, with strings. n this state, several rolls, each containing 40,000 or 0,000 needles, are placed in a machine exactly resembling an ordinary mangle, *i. e.* upon a board over which is made to move backward and forward, by means f a crank, and making ten or twelve movements in a minute, a weighted box of an oblong shape. In this manner the needles are rolled one against the other, midst the emery, for from two to three days; two or three wrappers being completely worn out, and the needles transferred to others, during that time. Out of the last of these wrappers they come perfectly clean and bright. The next operation, which is called in the manufactory

Heading and Picking, — consists in placing all the heads one way, and all the points another — a manipulation performed by children with a degree of expertness only attainable by much practice — and likewise in picking out from the whole heap the broken eyes and broken points, which, as may well be supposed, are very numerous in consequence of the severe operation last described; the former, of course, are thrown aside as wasters, the latter are generally repointed as blunts, and made up by themselves for sale.

The ingenious and profoundly scientific Mr. Babbage describes the last-mentioned operation with great distinctness, as exhibiting, in his opinion, one of the simplest contrivances that can with propriety be called a tool. The needles are placed sideways in a heap, on a table in front of the operator. From five to ten are rolled towards this person by the fore-finger of the left hand: this separates them a very small space from each other, and each in its turn is pushed lengthways to the right or to the left, according as its eye is on the right or the left hand. This is the usual process, and in it every needle passes individually under the finger of the operator. A small alteration expedites the process considerably: the child puts on the fore-finger of its right-hand a small cloth cap or finger-stall, and rolling from the heap from six to twelve needles, it keeps them down by the fore-finger of the left-hand; whilst it presses the fore-finger of the right-hand gently against the ends of the needles: those which have their points towards the right-hand stick into the finger-stall; and the child, removing the finger of the left-hand, allows the needles sticking into the cloth to be slightly raised, and then pushes them towards the left side. Those needles which had their eyes on the right-hand do not stick into the finger cover, and are pushed to the heap, on the right side, previous to the repetition of the process. By means of this simple contrivance, each movement of the finger from one side to the other carries five or six needles to their proper heap; whereas, in the former method, frequently only one was moved, and rarely more than two or three were transported at one movement to their place.

As diversities of manufacture, every user of very fine needles must of late years have heard of gold-eyed, and silver-eyed, and drilled-eyed needles, each sort equally "warranted not to cut the thread." It may be sufficient here to say, that the well-known appearance of the former is produced by dipping the head of the needle into the spirit of ether, containing a little gold in solution, and which immediately attaches itself to the steel, when dipped in the menstruum. Needles are sometimes treated with this ethereal solution of gold all over, in order to give them a beautiful yellow colour, and at the same time to prevent them from rusting. As to the second sort, not a particle of silver, or of any thing like it, is used, the peculiar white polish of the eye being communicated by means of its application to a little cylinder stuck full of steel pegs, like the small tune-barrel seen inside those musical boxes which are so common now-a-days. The drilled-eyes constitute a real improvement: not, indeed, that the eye itself is actually formed by drilling, any more than the silver-eyed needles owe any portion of their finish to that metal; but the eyes being countersunk, and smoothed on both sides by a drill after punching, they not only look well, but are, when carefully made, little, if at all, liable to cut the thread. They, likewise, rarely break in the eye, — the common fault of common needles, —because they are not only made of the very best material, but being moreover blued or softened, to allow the drill to cut, they are not so brittle as otherwise they would be.

Blue Pointing, — or the communicating of that exquisite polish which all the best needles are seen to possess, — is performed by applying them, several together, to a revolving stone about the size and shape of one's finger: this stone is of a slaty-blue colour, and comes from Warwickshire. This is generally the finishing operation; after which the needles are made up in little packages of a quarter of a hundred, labelled, and wrapped up in larger parcels for sale. The cheapness of the commoner sort of needles has frequently been the theme of wonder, with those persons who have considered the variety of manipulations through which they must have passed: on the other hand, needles of the most exquisite delicacy and finish exhibit one of the rarest proofs of the value conferred by manual labour upon a material in its original state of small nominal price; for some of the finest sorts are worth considerably more than their weight in gold.

We have now pursued our examination of iron and steel manufacture through all its modifications and varieties. It may not, in conclusion of this section, be uninteresting to notice the conditions of our produce of fossil fuel upon which so entirely depends our iron manufacture, now amounting to the value of at least 10,000,000*l.* annually. The coal fields of Great Britain and Ireland, which are also iron producing districts, amount to about 12.000 square miles. The produce of coal in Great Britain and some other coal producing states is as follows: —

Great Britain - -	31,500,000 tons.
United States - -	4,400,000 ,,
Belgium - - -	4,960,077 ,,
France - - -	4,141,617 ,,
Prussia - - -	3,500,000 ,,
Austria - - -	700,000 ,,

In Great Britain 229,182 people are employed in working coal and iron mines; in France the number is 31,283; in Belgium 41,298; in Pennsylvania 15,000.

The following quotation from Mr. McCulloch's Commercial Dictionary, most accurately expresses the value of our coal and iron formations.

"It is hardly possible to exaggerate the advantages England derives from her vast beds of coal. In this climate, fuel ranks among the necessaries of life, and it is to our coal mines that we owe abundant and cheap supplies of so indispensable an article. Our coal mines are the principal source and foundation of our manufacturing and commercial prosperity. Since the invention of the steam-engine, coal has become of the highest importance as a moving power; and no nation, however favourably situated in other respects, not plentifully supplied with this mineral, need hope to rival those that are, in most branches of manufacturing industry. To what is the astonishing increase of Glasgow, Manchester, Birmingham, Leeds, Sheffield, &c., and the comparatively stationary or declining state of Canterbury, Winchester, Salisbury, and other towns in the south of England to be ascribed?—The abundance of coal in the north, and its scarcity and consequent high price in the south, is the real cause of this striking discrepancy."

"Our coal mines have conferred a thousand times more real advantage on us, than we have derived from the conquest of the Mogul empire, or than we should have reaped from the dominions of Mexico and Peru. They have supplied our manufacturers and artisans with a power of unbounded energy and easy control;

and they have enabled them to overcome difficulties insurmountable by those to whom nature has been less liberal of her choicest gifts."

Yet with this enormous amount of wealth procured from the soil, and deposited and disposed therein according to fixed laws, by the study of which many a fearful wreck of capital would be saved, England remained until within the past two years, without a single establishment in which anything approaching to a knowledge of mining can be procured. All our speculations in mining are under the guidance of chance, whereas they might be reduced to comparative certainty. Let us hope, however, that this reflection will not be much longer cast in our teeth by our continental neighbours, since the government has established a mining school in connexion with the Museum of Practical Geology, and are endeavouring to encourage the institution of mining and industrial schools in the provinces.

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